APPENDIX A
THE LOWER ST. JOHNS RIVER BASIN TMDL EXECUTIVE COMMITTEE

This broad-based group was convened by the Department's Northeast District and has been meeting since July 2002. It has advised the Department on issues such as water quality targets and allocation processes. The committee will play a critical role in the development of the Basin Management Action Plan to implement TMDLs. The committee membership as of July 2003 is listed below:

Lower St. Johns River Basin TMDL Executive Committee	
Interest Group	**Representative**
Florida Department of Environmental Protection	Mario Taylor, Northeast District (Chair)
Industry	Mike Burch, Plant Manager, Rayonier
Agriculture	Wayne Smith, President, North Florida Growers Exchange
Builders	Neil Aikenhead, Northeast FL Builders Association
Utility Authorities	Susan Hughes, JEA
Environmental Interest Groups	Roger Bass, St. Johns River Keeper
	Don Loop, Stewards of the St. Johns River
Regional Planning Council	Brian Teeple, NE Florida Regional Planning Council
Forestry	Jim Kuhn, Shadow Lawn Farms
Local Government	Honorable Glen Lassiter, Clay County Commission
Florida Department of Agriculture & Consumer Services	Jody Lee, DACS
MSW – Public Works	Ed Hall, City of Jacksonville Public Works
St. Johns River Water Management District	Casey Fitzgerald (for Executive Director Kirby Green)
U.S. Army Corps of Engineers	Richard Bonner, USACOE

LSJR Executive Committee Mission Statement

The LSJR TMDL Executive Committee advises the Department on the development and implementation of TMDLs for the basin. The committee represents and communicates with key stakeholders to secure local input and consensus on pollutant reductions. The committee is charged with recommending a "reasonable and equitable" allocation of pollutant load reductions for achieving TMDLs in the lower basin and, in conjunction with the Department, developing a Basin Management Action Plan to implement those load reductions.

APPENDIX B
EUTROPHICATION DEFINED

Eutrophication is generally described as a process of changing the ecological status of a waterbody by increasing the baseline (e.g., primary) level of productivity, almost invariably as a result of increasing nutrient supply. Some researchers (Nixon, 1995) have suggested that estuarine eutrophication be defined as "an increase in the rate of supply of organic matter to an ecosystem," as the effect of eutrophication in most systems is an increase in plant (algae and/or nuisance aquatic plants) biomass.

The general sequence of eutrophication effects is as follows. In the enrichment phase, there is an episodic or continuous increase in algal and plant biomass. Above a certain level of nutrient availability, changes in plant species composition occur that can have profound effects on the habitat and structure of the rest of the food web, potentially affecting energy flow in the entire ecosystem. Secondary effects can include reductions in light penetration that can reduce the species composition and depth distribution of benthic plants, increased probability of the occurrence of toxic/nuisance phytoplankton blooms, hypoxia (commonly used to describe DO concentrations at or below 2.0 mg/L), and behavioral effects on other organisms in the food web (Gray, 1992). Extreme effects can include the mass growth of undesirable plants, regular blooms of toxigenic and other nuisance algae, and, ultimately, migration or mortality of various species.

APPENDIX C
BASIS FOR LSJR WATER QUALITY TARGETS

(Excerpts[1] from Hendrickson et al., 2003, *Characteristics of Accelerated Eutrophication in the Lower St. Johns River Estuary and Recommended Targets to Achieve Water Quality Goals for the Fulfillment of TMDL and PLRG Objectives*)

1 .

Water Quality Targets for the LSJR

Some measure of the three most commonly identified water quality effects of estuarine eutrophication—nuisance levels of algal biomass, reduced dissolved oxygen and reduced transparency—were recommended in the original Plan of Study (POS) document as the response variables in establishing nutrient TMDLs and PLRGs for the LSJR. These TMDL and PLRG targets were originally established consistent with standards or thresholds set forth in Chapter 62-302, F.A.C., and Chapter 62-303, F.A.C. However, in the process of data analysis and investigation to describe nutrient enrichment effects and to quantify these relationships through water quality modeling, these targets have undergone refinement in order to more closely address the most problematic aspects of eutrophication in the LSJR.

Relevant questions driving the re-definition of targets were:

1) Is the dissolved oxygen State standard sufficiently protective, or conversely, unnecessarily protective, for biota endemic to the LSJR?

2) Is the maintenance of transparency, based upon open water changes in compensation depth, relevant to SAV colonization in the LSJR?

3) Do algal biomass targets, based upon mean annual chlorophyll *a* concentrations, sufficiently address the most problematic aspects of nuisance algal blooms?

Because of the weak linkage between open water, planktonic algal attenuation that is embodied in the transparency standard as stated in Chapter 62-302, F.A.C., and the more realistic case of epiphytic algal attenuation for littoral submerged grasses, it was felt that the transparency criteria is not the appropriate target for protection of SAV in the LSJR. Investigations relating nutrient enrichment effects to SAV health, and the interactions between natural factors of light, color and substrate and nutrient enrichment are ongoing and can be used to revise the LSJR nutrient TMDL if warranted.

In light of the great amount of research in support of oxygen criteria, and the recent work accomplished in compiling and refining this research in EPA's *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras*, it was felt that sufficient effort could not be mustered, nor was warranted, to refute these recommendations for the LSJR TMDL. Therefore, methodologies provided in this guidance have been relied upon for establishing algal biomass targets for the predominantly marine reach of the river. While these methods apply a less restrictive criteria for maintenance of aquatic life based on dissolved oxygen than the current Florida Water Quality Standard, they are arguably more realistic given the natural stressors to oxygen level in a southern temperate blackwater river estuary.

And finally, as experimental evidence suggests that the greatest level of harm from algal blooms occurs from extreme bloom events, the chlorophyll *a* targets for the LSJR were redefined to emphasize the reduction of high concentration and long duration events.

LSJR Freshwater Phytoplankton Community Composition Dynamics and Zooplankton Interactions

The fundamental objective for LSJR TMDL and PLRG nutrient load reduction modeling was the enhancement of plankton ecology for both freshwater and marine environments. This approach was taken because 1) the LSJR is largely a plankton based system, with the majority of its autochthonous carbon produced through phytoplankton primary production, and 2) a large database composed of five years of phytoplankton and zooplankton monitoring data exists for the LSJR, representing the most powerful biological evaluation tool available.

For the freshwater river, three elements of plankton ecology were assessed:

1) What maximum levels of algal biomass maintain diversity in the plankton community?

2) What maximum levels of algal biomass, or what phytoplankton community composition, facilitates the upward transfer of planktonic primary production to higher trophic levels?

3) What levels of algal biomass minimize the potential for the expansion of detrimental algal species or the production of algal toxins?

Freshwater LSJR Algal Biomass Target

Maintenance of Phytoplankton Diversity

The maintenance of organism diversity is a fundamental goal of biological restoration. Diversity in biological systems promotes stability; conversely, ecosystems with narrow species diversity are prone to large perturbations in communities. The loss of phytoplankton diversity, and the dominance of cyanobacteria during the spring and summer growth seasons is one of the most conspicuous aspects of freshwater blooms of the LSJR. As total phytoplankton community biomass (expressed as chlorophyll *a*) increases, the fraction of the total community biomass composed of blue-greens (determined from biovolume estimates) increases (Figure 27). Blue green relative composition is variable and often low for chlorophyll *a* concentrations to about 40 mg/m^3. After this point, blue green biomass represents the majority of phytoplankton community composition. At chlorophyll *a* concentration above 60 mg/m^3, blue green relative abundance is regularly between 80 to 90 percent.

Facilitation of Upward Trophic Transfer of Primary Production

In its Chesapeake Bay Water Quality Criteria Guidance Manual, EPA outlines an approach to the development of chlorophyll *a* criteria for the purpose of enhancing the upward transfer of phytoplankton carbon to the zooplankton community. The conceptual model utilized in the Chesapeake Bay (CB) Guidance relating mesozooplankton response to increases in algal biomass is depicted in Figure 28. This model is based on the premise that at low to moderate phytoplankton densities, zooplankton populations respond favorably and increase with increase in algal biomass associated with increase in food supply. At some point, however, the increase in toxic or otherwise unpalatable taxa in the phytoplankton community, and an increase in feeding effort due to the density of unfavorable species, leads to a leveling off and perhaps even decline in the desirable zooplankton. The point of the departure from the linear increase in zooplankton – phytoplankton biomass represents the maximum desirable algal biomass.

Plankton monitoring data (Nov. 1996 through Oct. 2001) were examined to determine if a relationship similar to that described above existed for the freshwater LSJR. The zooplankton – algal biomass relationship is shown in Figure 29. Desirable zooplankton in these graphs are estimated by summing the organism counts for copepods and cladocerns only. Rotifers are excluded, as they are believed to be feeding on small detrital particles and bacteria, and are not believed to be as important a group of zooplankters in supporting the upward transfer of carbon to the fish community. Although a good deal of spread exists in this graph in zooplankton abundance at low to moderate chlorophyll *a* concentration, it is possible to discern a pattern that matches the conceptual model forwarded by the CB guidance.

This graph suggests that the linear increase in zooplankton abundance with increasing chlorophyll *a* concentration begins to decline somewhere between chlorophyll *a* concentrations of 40 to 60 mg/m^3. The adverse response of zooplankton numbers to high levels of algal biomass can be seen in Figure 29 for the specific case of the severe algal blooms that occurred at Racy Point in 1999. At this station, zooplankton numbers increase initially as chlorophyll concentration increases, but then decline as chlorophyll continues to increase. This pattern is repeated for the year's second bloom, which peaks in late August.

Algal Toxin Formation Potential

In recently completed work, Paerl and Charmichael (2002) examined levels of the algal toxins microcystin, anatoxin, and cylindrospermopsin in nutrient enrichment assays performed on LSJR samples collected from October 2000 through August 2001. All toxins were detected during the sampling, with microcystin present in every assay. Microcystin was found to be positively correlated to chlorophyll *a* (e.g., algal biomass), and this relationship is shown in Figure __. Generally, microcystin levels remained low for chlorophyll a concentrations below 40 µg/L. Above this level, microcystin levels were found to be variable, but on occasion reached very high levels, near the World Health Organization standard for drinking water of 1 µg/L. The LSJR is not a drinking water source, and relevance of this standard for the protection of aquatic life has not been quantified. However, the result of these assay experiments suggests that at concentrations of chlorophyll *a* that exceed 40 µg/L, the potential for the appearance of microcystin in ambient water increases greatly.

Algal Bloom Duration

Plankton monitoring data and algal toxin assays indicate that blue green algal blooms of the LSJR freshwater reach begin to exhibit detrimental effect as bloom biomass, measured as chlorophyll *a*, exceeds 40 mg/m^3. These effects would not be expected to be instantaneous at concentrations above 40 mg/m^3, but instead to require some level of duration and intensity. When the numbers of copepods and cladocerans (again, considered to be an indicator of beneficial zooplankton) in plankton sampling are compared to the durations of above 40 mg/m^3 chlorophyll *a* excursions (Figure 30), it can be see that as durations exceed 40 days, copepods and cladoceran numbers are noticeably reduced. In the duration analysis of Figure 10, between 20 to 45 percent of blooms within the freshwater reach exceeded this duration.

The mean duration of above 40 mg/m^3 episodes is between 20 to 30 days within the freshwater reach (Figure 10), but bloom duration increases disproportionately as blooms exceed 30 days. For example, the increase in duration from the 40^{th} percentile bloom to the 50^{th} percentile is approximately 10 days, while the increase from the 50^{th} to the 60^{th} percentile event is on the order of 20 days. When the maximum concentration of blooms is compared to the bloom duration (Figure 31), the maximum concentrations (based on the linear regressions) corresponding to 40-day durations range between 50 to 74 mg/m^3 chlorophyll *a*. Using the Racy Point station data, it is possible to parameterize a new distribution of chlorophyll *a* that hypothetically would meet the conditions for the maintenance of phytoplankton and zooplankton diversity. This was done by proportionally scaling the synthesized statistical distribution of the existing data (shown in Figure 32 by the dark navy blue line; the natural log of chlorophyll *a* is used to normalize the distribution) to form a new distribution (Figure 32 light blue line) for which the 1 percentile occurrence was the same as the observed data, and the 99^{th} percentile occurrence (p = 0.01 for a one tailed test) was equivalent to a chlorophyll *a* of 74 mg/m^3. This synthesized distribution had a mean of 20.1 mg/m^3, a variance of 0.56 mg/m^3, and a 10.6 percent occurrence rate for chlorophyll *a* concentrations greater than 40 mg/m^3.

Marine LSJR Dissolved Oxygen Targets

Dissolved Oxygen Effects

As demonstrated in the previous section outlining eutrophication effects, low dissolved oxygen excursions (persistent episodes below the State criteria of 5 mg/L) occur in both the freshwater and oligo/mesohaline reaches of the LSJR. These excursions occur coincident with high summertime temperatures, and appear to be associated with the decline or crash of significant algal blooms, and on an inter-annual basis are correlated with mean spring-summer algal biomass levels. The improvement of the dissolved oxygen regime for the river and estuary was one of the originally stated objectives of the TMDL and PLRG plan for the river, and the State standard of 5 mg/L (instantaneous for freshwater reaches, and as a daily average for predominantly marine reaches) was identified as the target on which to base nutrient reduction scenario modeling. Even at the time of the proposition of this target, however, considerable uncertainty existed regarding its appropriateness and achievability. Low dissolved oxygen episodes have long been known to occur in southeast U.S. estuaries (Schroeder and Wiseman, 1988), and naturally low dissolved oxygen concentrations are known to be a feature of blackwater river systems. For these reasons, effort has been directed toward refining oxygen regime targets that are based upon the minimum levels necessary for the protection of native estuarine aquatic communities.

As an alternative to the fixed standard of 5 mg/L, the procedure described in the recently published U.S. Environmental Protection Agency Guidance, *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hattaras*, (U.S. EPA, 200) has been used to define the dissolved oxygen target on which reductions of nutrient enrichment effects are to be based. The *Guidance* contains several elements that offer superiority over the oxygen standard of *F.A.C.* 62-302. First, it is based upon the tolerance of low oxygen by estuarine fish and invertebrates, as opposed to both fresh and saltwater species. Second, the *Guidance* establishes an absolute minimum oxygen level for the protection of most estuarine species against acute low concentrations that result in organism mortality, and distinguishes this level from a sub-lethal range that results in reductions in growth and recruitment, and with this, presumably fish health and survival probability. Fish community effects within this sub-lethal range are based upon the intensity and duration of hypoxic events. Third, the *Guidance* offers approaches for assessing effects of two common types of low dissolved oxygen common to eutrophic estuaries: persistent, low dissolved oxygen associated with late season algal bloom decline; and diurnal patterns of low oxygen associated with high algal standing stock photosynthesis and respiration cycles or tidal transport of low oxygen water masses. In the LSJR, the most common and severe low oxygen episodes are long term, persistent events associated with late season algal community decline, and the *Guidance* procedure for assessing these types of events has been used to define oxygen targets.

Organism Acute Oxygen Levels

The data set used in the *Guidance* to develop criteria minimum concentration (CMC) was assimilated from previous studies that examined species or genus-specific survival under continuous low dissolved oxygen exposures. These studies covered 12 invertebrate and 11 fish estuarine species, mostly at juvenile life stages. The Florida Marine Research Institute’s Fisheries Independent Monitoring Program (FMRI, 2002) has confirmed the presence of five of these species in the northeast Florida region (includes one site in the St. Mary’s River, one in the Nassau, and 3 in the lower St. Johns estuary), and these are listed in Table 4. Because the FMRI sampling is performed using river seines, haul seines and otter trawls, some benthic invertebrate species may be under-reported. A trend is evident between the numbers of individuals of a given species present in the FMRI sampling, and their low oxygen LC50, in that as an individual species low dissolved oxygen tolerance decreases, its abundance declines in the northeast Florida sampling region (Figure 33). A numbers of factors could account for this, including species natural ranges, sampling methodology, migration patterns or competitive interactions, though the possibility that these species are excluded due to prevailing low dissolved oxygen, either as a natural occurrence or through accelerated eutrophication, should be considered as a contributing factor.

Following the procedure established in the development of toxics criteria, the CMC is determined by adjusting upward LC50 data to estimate the LC5 concentration, using the mean LC5/LC50 ratio for all studies, applied to the most sensitive species mean acute value (SMAV). In the studies compiled in the *Guidance*, pipe fish (*Syngnathus fuscus*), exhibited the highest SMAC, at an LC50 concentration of 1.63 mg/L. Pipe fish was reported in northeast Florida region in the FMRI sampling, but in only one sampling event. For spot (*Leiostomus xanthurus*) the most commonly seen species in the northeast Florida region for which a SMAV is reported, the *Guidance* lists a SMAV of 0.70 mg/L, considerably lower that that of pipe fish. Following the approach used in toxics criteria development, the *Guidance* uses the mean LC5/LC50 ratio, here given as 1.38, to adjust upward the maximum tolerable acute value. Thus the CMC that is considered as protective of most species is give as 2.3 mg/L, and this value has been used for the assessment of low dissolved oxygen effects in the LSJR estuary.

Growth Effects

To develop a measure of sub-lethal effects due to low dissolved oxygen, the *Guidance* relied upon previous studies that examined reductions in fish growth, usually during larval or juvenile life stages, due to low dissolved oxygen concentration. Growth is usually more sensitive than survival to low dissolved concentrations, though the *Guidance* notes several exceptions in which studies report greater rates of mortality than growth reduction. In general, invertebrates exhibit low acute dissolved oxygen concentrations, but a large range in growth reduction. Fish, on the other hand, exhibit higher acute concentrations but a relatively narrow range in growth reduction, and it is not unusual for fish species to exhibit considerable overlap in oxygen levels that cause mortality and growth reduction. Based upon a smaller number of studies that reported similar reductions in reproductive success at low dissolved oxygen levels, the *Guidance* concluded that oxygen levels that are protective of growth effects would also likely be protective of reproductive success.

Of the 11 species for which growth effects data were found, 2 were collected in FMRI sampling: summer flounder (*Paralichthys dentatus*), a total of 9 individuals collected, and sheepshead minnow (*Cyprinodon variegates*), a total of 3 individuals collected. One of the most commonly caught fish in the FMRI sampling, silverside (*Menidia* spp.), at 10,342 individuals collected, is also listed in the Guidance growth effects data, though specifically for *Menidia menidia*, Atlantic silverside. The reported no observed effects levels (concentrations above which one would expect no reduction in growth) for summer flounder, sheepshead minnow, and Atlantic silverside are 4.39 – 7.23, 2.5 – 7.5, and 3.9, respectively. Based upon these ranges, it appears that the final chronic value (FCV) at which low dissolved oxygen is not expected to effect growth of 4.8 mg/L is appropriate for northeast Florida.

Larval Recruitment

To estimate the effects of hypoxic conditions at concentrations between 2.3 and 4.8 mg/L, the *Guidance* applies a larval recruitment model to estimate the number of individuals that are "recruited" from early life stages to juvenile stage. This model is based upon larval development time, larval season, attrition rate and patterns of vertical distribution. Nine genus had sufficient data to parameterize the model as developed in the *Guidance*. Two of these, *Menidia* and *Scianops*, are known to be present in northeast Florida based upon the FMRI sampling. The model develops recruitment curves based on the intensity and duration of low dissolved oxygen, and genus-specific curves for the two species found in northeast Florida developed the lowest and third lowest curves (Figure below from *Guidance*).

The larval recruitment model can be adapted with regionally specific data. However, due to lack of specific data for northeast Florida species, and the possibility that species that have not been collected in the FMRI sampling program have been excluded due to human-induced changes in oxygen regime, the model formulation as provided in the *Guidance* has been used for the LSJR TMDL/PLRG process.

Additional Considerations

The methodology descried in the EPA estuarine dissolved oxygen guidance addresses only acute and chronic (growth) direct effects from low dissolved oxygen.   Because of predator-prey interactions, the timing of reproductive activities, additional stressor effects under conditions of nutrient enrichment and eutrophication, direct effects may be mitigated or enhanced. Breitburg (2002), in her review of hypoxia effects on coastal fisheries, addresses many of the permutations of trophic alterations that may potentially occur.

While the approach used is expected to be appropriate for other regions outside the Virginian Province estuaries, the *Guidance* does note that animals may have adapted to lower oxygen levels in regions of higher temperatures or with naturally high demands for dissolved oxygen. In particular, it may be appropriate at some point to develop regionally specific data for revising the larval recruitment model on which cumulative, sub-lethal effects are based. However, based upon the presence of species in northeast Florida that have been shown to exhibit reduced growth in the range of dissolved oxygen between 4 and 5 mg/L, and the possibility that certain species that are not shown to be present in this region from the FMRI sampling have been excluded due to human-induced reductions in dissolved oxygen, it is felt that the larval recruitment model represents a conservative estimate of potential harm that is less restrictive that the application of a strict 5 mg/L standard.

Application of the Criteria

The maximum acute value, growth effects threshold and larval recruitment model are combined into one relationship relating the intensity and duration of a given continuous, low dissolved oxygen event. This approach is graphically depicted in Figure 34. Above 4.8 mg/L, pelagic, estuarine organisms are assumed to suffer no chronic effect from hypoxia (defined as dissolved oxygen below saturation concentration; oxygen saturation concentration at 30 ^{o}C. and 15 ppt chlorinity = 6.5 mg/L). Oxygen levels below 2.3 mg/L are expected to have acute lethal effects to at least some organisms. Between these two values, the degree of mortality in the population is proportional to the duration of exposure, and the compilation of data from numerous dose-response studies was used to develop the relationship seen in this figure. A given interval of low dissolved oxygen is considered to be a "dose" of potentially low dissolved oxygen, and is expressed as the fraction of the total duration of the interval at that concentration needed to cause mortality in at least 5 percent of the most sensitive species of the fish community. For example, the impairment index calculated duration of exposure to dissolved oxygen at 3 mg/L is 5.57 days. A one day duration of 3 mg/L dissolved oxygen is considered to be 1/5.57 or 18 percent of a lethal dose. Individual doses of continuous exposure that sum up to greater than 1 are considered to be a lethal dose.

Following the approach, 3 out of the 6 years of data collected at the Dames Point station exhibited one, long excursion of continuous low D.O., with durations from 4 to 7 weeks. Calculated impairment scores for Dames Point were 1.74, 3.57, and 1.07 for 1997,1999 and 2001. In 1999, a large fish kill of many thousands of adult shad and menhaden occurred in this reach of the river, associated with this low D.O. event. No low D.O. events were measured at the Acosta Bridge station between 1996 and 2001 that qualify for chronic impairment under the EPA guidance approach, with the greatest score being 0.73, recorded in 1998.

Dinoflagellate Bloom Potential

The potential for nutrient and organic matter enrichment to stimulate the growth of marine dinoflagellate algal species represents one of the most significant detrimental effects attributable to estuarine eutrophication. Several toxic dinoflagellate species have been identified in regular plankton monitoring, including *Karolina breve* (red tide) and *Prorocentrum minimum*, and dinoflagellate infections have been postulated as a possible factor in ulcerative disease syndrome that plagued the LSJR during much of the early 1990's. A monitoring program conducted in 19__ with the objective of determining the presence of *Pfiesteria*–like species discovered a previously unidentified dinoflagellate, subsequently named *Cryptoperidineopsis brodii*, to reside in LSJR mesohaline reach sediments.

The tendency for dinoflagellate populations to increase in relative abundance under conditions of increasing potential diatom silica limitation leads to the possibility that high levels of nutrient enrichment, in excess of that balanced by bioavailable silica, may contribute disproportionately to dinoflagellate blooms. Dinoflagellate life cycles and survival strategies are extremely complex, however, and occurrence of high populations is poorly correlated with nutrient concentration or diatom biomass. For this reason, the limitation of dinoflagellate blooms exists as a qualitative target in LSJR TMDL development. In recent work investigating the relationship between nutrient enrichment effects on nuisance algal growth in the Indian River Lagoon, the occurrence of potentially toxic dinoflagellate blooms is identified as a significant water quality impairment (Phlips *et al.,* 2003)). In this work, a level of 1,000,000 μm^3/ml algal biovolume (roughly equivalent 6 µg/L chlorophyll *a*) is suggested to define a marine bloom condition.

APPENDIX D
ESTIMATED LOADS TO THE LSJR
FOR 1995–99

Table D1. Summary of Loads to the Lower St. Johns River, 1995. All values in metric tons per year.

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N		Total P	Labile TNOP	Refractory TNOP	Total PO4		Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	10765.1	4336.2	5373.0	1056.0		511.2	207.3	96.9	207.0		138347.0	12976.2	125370.9
Natural Background	6659.7	1006.7	5432.5	220.5		290.8	97.9	97.3	95.6		131539.8	5727.6	125812.3
Dunns Creek Total	1372.5	290.7	919.0	162.8		108.2	33.6	35.4	39.1		23100.5	718.7	22381.9
Natural Background	915.7	112.0	779.9	23.7		61.3	15.0	31.4	14.9		19272.6	636.9	18635.7
Upstream Total	12137.7	4627.0	6291.9	1218.8		619.3	240.9	132.3	246.1		161447.5	13694.8	147752.7
Fresh Tidal NP Total	1068.4	371.7	505.6	191.1		211.2	54.9	22.7	133.6		23875.4	1709.8	22165.6
Natural Nonpoint	626.3	203.8	387.9	34.6		56.8	11.1	6.7	38.9		23213.7	1255.7	21957.9
Agriculture Contribution	384.1	126.1	124.7	133.4		136.9	35.4	13.4	88.1		217.9	173.7	44.2
Urban Contribution	53.2	39.3	-3.5	17.4		15.4	8.5	1.7	5.2		-507.8	171.4	-679.2
Other Nonpoint	4.7	2.5	-3.5	5.7		2.1	-0.1	0.9	1.3		951.7	109.0	842.7
Point Source	306.7	151.5	12.0	143.2		70.2	32.0	0.8	37.4		1417.6	814.6	603.0
Oligohaline NP Total	1141.3	517.8	447.3	176.3		186.8	79.2	16.7	90.9		25692.0	2584.6	23107.4
Natural Nonpoint	746.3	236.9	468.9	40.5		65.6	13.0	8.3	44.2		26852.0	1413.6	25438.4
Agriculture Contribution	26.2	10.7	2.0	13.5		10.9	2.1	0.5	8.3		1.5	46.5	-45.0
Urban Contribution	370.7	269.2	-10.1	111.6		110.0	64.0	7.8	38.2		-2062.9	1028.6	-3091.5
Other Nonpoint	-1.8	1.0	-13.5	10.7		0.5	0.0	0.2	0.3		901.5	96.0	805.5
Point Source	333.5	49.6	3.9	279.9		72.1	11.2	0.3	60.6		287.1	165.0	122.1
Meso-Polyhaline NP Total	440.2	223.2	120.6	96.4		92.0	44.0	6.6	41.4		6524.5	1002.8	5521.6
Natural Nonpoint	218.4	68.0	138.5	11.9		19.8	3.8	2.5	13.6		7509.0	385.0	7124.1
Agriculture Contribution	13.4	5.3	1.1	7.0		5.3	1.2	0.2	4.0		17.4	20.2	-2.8
Urban Contribution	209.9	151.9	-10.7	68.8		66.6	39.2	3.8	23.6		-1238.7	567.6	-1806.3
Other Nonpoint	-1.5	-2.1	-8.2	8.8		0.2	-0.2	0.2	0.2		236.7	30.1	206.6
Point Source	1147.4	238.9	18.9	889.6		294.4	46.9	1.2	246.2		1920.7	1103.7	817.0
Total Atmospheric Dep.	243.0					5.0							
LSJRB Summary													
Total Natural Nonpoint	1591.0	508.7	995.3	86.9		142.2	28.0	17.5	96.7		57574.7	3054.3	54520.4
Total Augmented Nonpoint	1059.0	603.9	78.2	376.8		347.9	150.2	28.6	169.1		-1482.8	2243.0	-3725.8
Total Point Source	1787.6	440.0	34.9	1312.7		436.6	90.2	2.3	344.2		3625.4	2083.3	1542.1
Grand Total	**16818.3**	**6179.6**	**7400.4**	**2995.2**		**1551.0**	**509.2**	**180.6**	**856.1**		**221164.9**	**21075.5**	**200089.4**
Notes: N= Nitrogen; P=Phosphorus; C=Carbon. NP=Nonpoint Sources. LSJRB Summary sums loads for only the LSJRB downstream of Dunns Creek.													

Table D2. Summary of Loads to the Lower St. Johns River, 1996. All values in metric tons per year.

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N		Total P	Labile TNOP	Refractory TNOP	Total PO4		Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	8609.9	4828.1	3252.4	529.4		385.0	241.4	48.1	95.3		103597.6	17027.1	86570.5
Natural Background	4451.6	1100.3	3252.4	98.9		221.1	122.7	48.1	50.4		92828.8	6258.3	86570.5
Dunns Creek Total	898.0	172.5	595.7	129.8		42.5	11.8	13.7	17.1		16639.5	523.2	16116.3
Natural Background	716.0	85.8	595.7	34.5		34.1	9.6	13.7	10.9		16604.5	488.2	16116.3
Upstream Total	9507.9	5000.6	3848.1	659.2		427.5	253.2	61.7	112.5		120237.1	17550.3	102686.8
Fresh Tidal NP Total	578.6	187.5	289.3	101.8		93.6	25.7	11.5	56.4		13718.0	869.5	12848.4
Natural Nonpoint	365.6	105.5	243.7	16.5		32.0	6.0	4.5	21.5		13597.2	623.4	12973.8
Agriculture Contribution	177.0	56.0	49.7	71.3		51.8	15.0	5.6	31.2		-24.3	88.7	-113.0
Urban Contribution	30.8	25.7	-5.1	10.2		8.6	4.7	0.9	2.9		-334.6	118.2	-452.8
Other Nonpoint	5.2	0.3	1.0	3.9		1.3	0.0	0.6	0.7		479.7	39.2	440.4
Point Source	285.6	144.6	11.5	129.6		66.0	30.5	0.8	34.7		1340.4	770.2	570.1
Oligohaline NP Total	676.8	300.0	264.0	112.8		113.7	47.0	10.1	56.6		14393.1	1440.3	12952.7
Natural Nonpoint	427.3	124.3	281.9	21.0		38.3	7.1	5.2	26.1		15176.5	707.0	14469.4
Agriculture Contribution	18.0	7.2	1.8	9.0		6.6	1.2	0.2	5.1		8.0	29.6	-21.5
Urban Contribution	230.5	51.4	-13.5	77.0		68.0	38.6	4.5	24.9		-1383.4	645.9	-2029.3
Other Nonpoint	1.0	117.0	-6.2	5.8		0.8	0.1	0.2	0.4		592.0	57.8	534.2
Point Source	322.5	42.3	3.4	276.8		65.6	10.5	0.3	54.9		351.8	202.2	149.7
Meso-Polyhaline NP Total	422.7	210.3	119.2	93.2		87.2	39.6	6.3	41.3		6400.3	949.3	5451.0
Natural Nonpoint	211.3	62.5	137.7	11.0		19.6	3.5	2.5	13.5		7243.0	345.8	6897.3
Agriculture Contribution	17.8	6.6	1.8	9.4		7.5	1.6	0.3	5.6		42.9	25.0	17.9
Urban Contribution	193.3	141.7	-14.2	65.8		59.4	34.5	3.3	21.6		-1161.2	545.2	-1706.4
Other Nonpoint	0.4	-0.6	-6.2	7.1		0.8	-0.1	0.3	0.6		275.6	33.3	242.3
Point Source	1144.4	251.6	20.0	872.9		328.9	50.8	1.3	276.9		2199.7	1264.0	935.7
Total Atmospheric Dep.	243.0					5.0							
LSJRB Summary													
Total Natural Nonpoint	1004.2	292.3	663.4	48.5		89.8	16.6	12.1	61.2		36016.7	1676.3	34340.5
Total Augmented Nonpoint	673.9	405.5	9.1	259.3		204.6	95.7	15.8	93.1		-1505.4	1582.9	-3088.3
Total Point Source	1752.5	438.5	34.8	1279.3		460.5	91.7	2.3	366.5		3891.9	2236.4	1655.4
Grand Total	**13181.5**	**6136.9**	**4555.3**	**2246.3**		**1187.5**	**457.1**	**91.9**	**633.2**		**#####**	**23045.9**	**135594.5**

Table D3. Summary of Loads to the Lower St. Johns River, 1997. All values in metric tons per year.

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N	Total P	Labile TNOP	Refractory TNOP	Total PO4	Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	4849.3	3606.6	1061.3	181.4	173.2	148.6	12.9	11.6	55541.4	17236.2	38305.2
Natural Background	1880.2	792.5	1061.3	26.4	117.5	85.7	12.9	18.8	42814.0	4508.8	38305.2
Dunns Creek Total	933.4	318.0	564.3	51.2	59.9	27.1	15.6	17.2	17202.9	996.6	16206.3
Natural Background	711.2	133.1	564.3	13.8	35.8	15.2	15.6	4.9	16963.6	757.3	16206.3
Upstream Total	5782.7	3924.6	1625.5	232.6	233.1	175.7	28.6	28.8	72744.4	18232.8	54511.5
Fresh Tidal NP Total	992.8	341.2	430.4	221.2	158.4	54.4	20.6	83.4	20214.2	1522.6	18691.6
Natural Nonpoint	532.7	181.2	321.9	29.6	44.8	9.7	5.5	29.5	20183.5	1163.8	19019.7
Agriculture Contribution	405.3	122.0	109.6	173.7	97.5	35.5	12.1	49.9	-112.0	132.2	-244.1
Urban Contribution	49.1	39.2	-1.0	10.9	14.4	9.0	2.0	3.4	-439.7	167.9	-607.6
Other Nonpoint	5.7	-1.2	0.0	7.0	1.7	0.1	1.0	0.5	582.3	58.7	523.6
Point Source	299.6	86.6	73.1	139.7	69.1	24.0	7.0	38.1	4789.3	585.6	4203.6
Oligohaline NP Total	728.4	325.9	302.4	100.1	110.4	46.5	10.8	53.0	17709.8	1684.1	16025.7
Natural Nonpoint	501.7	163.3	310.9	27.4	42.8	8.9	5.4	28.4	18268.7	996.5	17272.1
Agriculture Contribution	16.4	6.8	1.3	8.4	6.9	1.3	0.3	5.3	-8.7	30.0	-38.7
Urban Contribution	211.9	156.1	-1.4	57.3	60.6	36.3	5.0	19.3	-1101.0	602.7	-1703.7
Other Nonpoint	-1.6	-0.3	-8.3	7.0	0.1	0.0	0.1	0.0	550.9	54.9	496.0
Point Source	341.3	45.9	9.8	285.6	73.6	11.5	0.7	61.5	321.6	143.8	177.8
Meso-Polyhaline NP Total	342.7	182.4	88.7	71.6	69.6	35.1	4.7	29.8	4914.8	822.6	4092.2
Natural Nonpoint	162.7	52.0	101.9	8.8	13.9	2.9	1.8	9.2	5644.2	300.8	5343.4
Agriculture Contribution	9.9	4.0	0.4	5.5	3.5	0.6	0.0	2.9	-8.1	14.7	-22.8
Urban Contribution	170.9	128.3	-8.5	51.1	52.0	31.6	2.7	17.7	-865.4	490.0	-1355.4
Other Nonpoint	-0.8	-1.9	-5.0	6.1	0.2	0.1	0.2	-0.1	144.1	17.0	127.1
Point Source	1187.7	251.1	33.7	902.9	334.6	71.4	3.1	260.1	2233.5	1354.5	879.0
Total Atmospheric Dep.	243.0				5.0						
LSJRB Summary											
Total Natural Nonpoint	1197.1	396.5	734.6	65.9	101.4	21.5	12.7	67.2	44096.4	2461.2	41635.2
Total Augmented Nonpoint	867.0	453.0	87.0	327.0	236.9	114.6	23.3	99.0	-1257.7	1568.1	-2825.7
Total Point Source	1828.6	383.6	116.6	1328.2	477.4	106.9	10.8	359.7	7344.4	2083.9	5260.5
Grand Total	**9918.4**	**5157.8**	**2563.7**	**1953.6**	**1053.8**	**418.7**	**75.4**	**554.7**	**#####**	**24346.0**	**98581.5**

Table D4. Summary of Loads to the Lower St. Johns River, 1998. All values in metric tons per year.

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N		Total P	Labile TNOP	Refractory TNOP	Total PO4		Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	8561.5	4942.4	3175.9	443.1		341.8	201.8	42.5	97.4		127323.1	21218.1	106105.0
Natural Background	4428.1	1189.7	3175.9	62.5		246.4	140.0	42.5	63.9		112873.9	6768.9	106105.0
Dunns Creek Total	971.2	217.6	681.9	71.7		51.3	15.8	15.9	19.7		21379.6	778.7	20600.9
Natural Background	813.6	108.2	681.9	23.5		39.4	11.1	15.9	12.4		21216.6	615.7	20600.9
Upstream Total	9532.7	5160.0	3857.8	514.9		393.1	217.6	58.4	117.1		148702.7	21996.9	126705.9
Fresh Tidal NP Total	1652.2	480.2	935.0	237.0		222.9	53.8	31.1	138.0		44053.4	2272.1	41781.4
Natural Nonpoint	1188.3	284.7	864.2	39.4		103.4	17.3	16.7	69.4		43976.7	1525.1	42451.6
Agriculture Contribution	350.3	111.7	93.9	144.7		92.2	27.3	11.9	53.0		-257.6	256.3	-513.9
Urban Contribution	110.4	92.5	-21.4	39.4		25.8	13.4	2.8	9.6		-817.6	443.8	-1261.4
Other Nonpoint	3.1	-8.7	-1.7	13.6		1.5	-4.2	-0.2	5.9		1151.9	47.0	1105.0
Point Source	274.2	82.4	57.1	134.5		62.1	21.9	5.1	35.0		4154.4	582.3	3572.2
Oligohaline NP Total	1236.9	492.7	565.8	178.4		171.8	63.8	18.4	89.6		28792.1	2331.6	26460.5
Natural Nonpoint	830.1	199.7	601.6	28.8		72.4	12.1	11.6	48.7		29623.8	1041.0	28582.8
Agriculture Contribution	35.9	17.9	9.5	8.5		8.7	5.9	2.4	0.5		-51.2	53.9	-105.1
Urban Contribution	374.4	282.0	-33.2	125.6		90.6	50.4	6.3	33.9		-1540.4	1200.2	-2740.6
Other Nonpoint	-3.5	-6.9	-12.1	15.4		0.1	-4.5	-1.9	6.5		759.8	36.5	723.3
Point Source	301.3	53.7	9.6	238.0		81.4	13.2	0.7	67.5		363.5	184.3	179.2
Meso-Polyhaline NP Total	867.0	436.2	254.1	176.7		152.0	68.5	11.4	72.1		13343.1	1966.9	11376.3
Natural Nonpoint	426.5	109.6	299.9	17.0		37.7	6.5	5.7	25.5		14672.1	570.9	14101.2
Agriculture Contribution	38.3	7.3	-1.5	32.5		11.8	-3.1	-1.1	16.1		29.8	49.8	-20.0
Urban Contribution	404.1	315.7	-40.2	128.6		101.5	59.8	4.8	36.9		-1741.7	1310.4	-3052.1
Other Nonpoint	-1.8	3.6	-4.1	-1.3		0.9	5.3	2.0	-6.3		382.9	35.8	347.1
Point Source	1267.0	279.4	38.3	949.3		341.5	70.7	3.3	267.6		2468.4	1500.7	967.7
Total Atmospheric Dep.	243.0					5.0							
LSJRB Summary													
Total Natural Nonpoint	2444.9	594.0	1765.7	85.2		213.5	35.8	34.0	143.6		88272.7	3137.0	85135.7
Total Augmented Nonpoint	1311.2	815.2	-10.8	506.8		333.2	150.3	26.8	156.1		-2084.0	3433.6	-5517.6
Total Point Source	1842.4	415.5	105.1	1321.8		485.0	105.8	9.1	370.1		6986.3	2267.2	4719.1
Grand Total	**15374.2**	**6984.7**	**5717.8**	**2428.7**		**1429.8**	**509.5**	**128.4**	**786.9**		**241877.7**	**30834.6**	**211043.1**

Table D5. Summary of Loads to the Lower St. Johns River, 1999. All values in metric tons per year.

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N	Total P	Labile TNOP	Refractory TNOP	Total PO4	Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	5280.2	3876.3	1268.0	182.0	183.4	150.2	17.2	17.9	62627.4	17164.1	45463.3
Natural Background	2091.0	815.0	1250.3	25.7	121.3	83.3	16.9	21.1	50350.1	4637.0	45713.1
Dunns Creek Total	-166.6	-120.9	-45.0	-0.8	-8.9	-6.5	-1.9	-0.6	-1443.5	-401.8	-1041.7
Natural Background	-80.4	-35.3	-45.2	0.2	-3.9	-2.0	-1.9	0.0	-1263.6	-201.0	-1062.6
Upstream Total	5113.6	3755.4	1223.0	181.2	174.5	143.7	15.3	17.4	61183.8	16762.3	44421.6
Fresh Tidal NP Total	248.7	84.8	119.4	44.5	54.5	13.4	5.6	35.5	5143.3	352.4	4790.9
Natural Nonpoint	139.6	39.3	93.9	6.5	13.2	2.3	1.7	9.2	5064.1	221.0	4843.1
Agriculture Contribution	103.1	35.0	35.1	33.0	38.9	9.6	3.7	25.6	64.3	46.8	17.5
Urban Contribution	9.3	7.6	-1.4	3.2	2.6	1.5	0.2	0.9	-90.9	32.7	-123.5
Other Nonpoint	-3.3	3.0	-8.1	1.8	-0.2	0.0	0.0	-0.3	105.7	51.9	53.8
Point Source	275.3	144.0	11.4	119.8	64.5	30.3	0.8	33.4	1232.2	708.0	524.1
Oligohaline NP Total	236.9	103.3	93.4	40.2	40.8	16.0	3.6	21.2	5286.4	512.6	4773.7
Natural Nonpoint	162.4	45.3	109.1	7.9	15.6	2.6	2.0	10.9	5700.0	247.9	5452.1
Agriculture Contribution	5.9	2.3	0.5	3.1	2.6	0.5	0.1	2.0	9.5	10.2	-0.8
Urban Contribution	74.9	51.9	-3.5	26.5	23.4	12.8	1.7	9.0	-494.5	197.1	-691.6
Other Nonpoint	-6.3	3.8	-12.7	2.6	-0.8	0.1	-0.2	-0.7	71.4	57.3	14.0
Point Source	305.2	46.3	3.7	255.2	81.9	13.1	0.3	68.5	249.4	143.3	106.1
Meso-Polyhaline NP Total	156.5	76.9	44.0	35.7	33.1	14.9	2.4	15.9	2332.0	342.7	1989.3
Natural Nonpoint	79.9	21.9	54.1	3.9	7.6	1.3	1.0	5.4	2719.0	116.0	2603.0
Agriculture Contribution	6.9	2.6	0.8	3.6	2.8	0.6	0.1	2.0	16.6	9.6	7.0
Urban Contribution	71.4	51.6	-5.6	25.5	22.8	13.0	1.2	8.5	-451.4	195.3	-646.7
Other Nonpoint	-1.8	0.8	-5.3	2.7	0.0	0.0	0.0	0.0	47.9	21.8	26.1
Point Source	1121.5	206.0	16.3	899.2	330.3	50.0	1.2	279.1	1401.0	805.1	595.9
Total Atmospheric Dep.	243.0				5.0						
LSJRB Summary											
Total Natural Nonpoint	381.9	106.5	257.1	18.3	36.4	6.2	4.8	25.5	13483.1	584.9	12898.2
Total Augmented Nonpoint	260.2	158.5	-0.3	102.0	92.0	38.1	6.8	47.0	-721.5	622.8	-1344.2
Total Point Source	1702.0	396.4	31.4	1274.2	476.7	93.4	2.3	381.0	2882.5	1656.4	1226.1
Grand Total	**7700.7**	**4416.8**	**1511.2**	**1575.7**	**784.6**	**281.4**	**29.2**	**470.9**	**76828.0**	**19626.4**	**57201.6**

APPENDIX E
DESCRIPTION OF STATE AND FEDERAL STORMWATER PROGRAMS

State and Federal Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, Florida Statutes (F.S.), was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, Florida Administrative Code (F.A.C.).

The rule requires the water management districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this study was conducted.

In 1987, the U.S. Congress established Section 402(p) as part of the Federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal National Pollutant Discharge Elimination System (NPDES) to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000 {which are better known as "municipal separate storm sewer systems" [MS4s]). However, because the master drainage systems of most local governments in Florida are interconnected, the EPA has implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the Department of Transportation throughout the fifteen counties meeting the population criteria.

An important difference between the federal and the state stormwater permitting programs is that the federal program covers both new and existing discharges, while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES stormwater permitting program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. The Department recently accepted delegation from the EPA for the stormwater part of the NPDES Program. It should be noted that most MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

APPENDIX F
EXAMPLE OF DO CALIBRATION FIGURES FOR THE WATER QUALITY MODEL

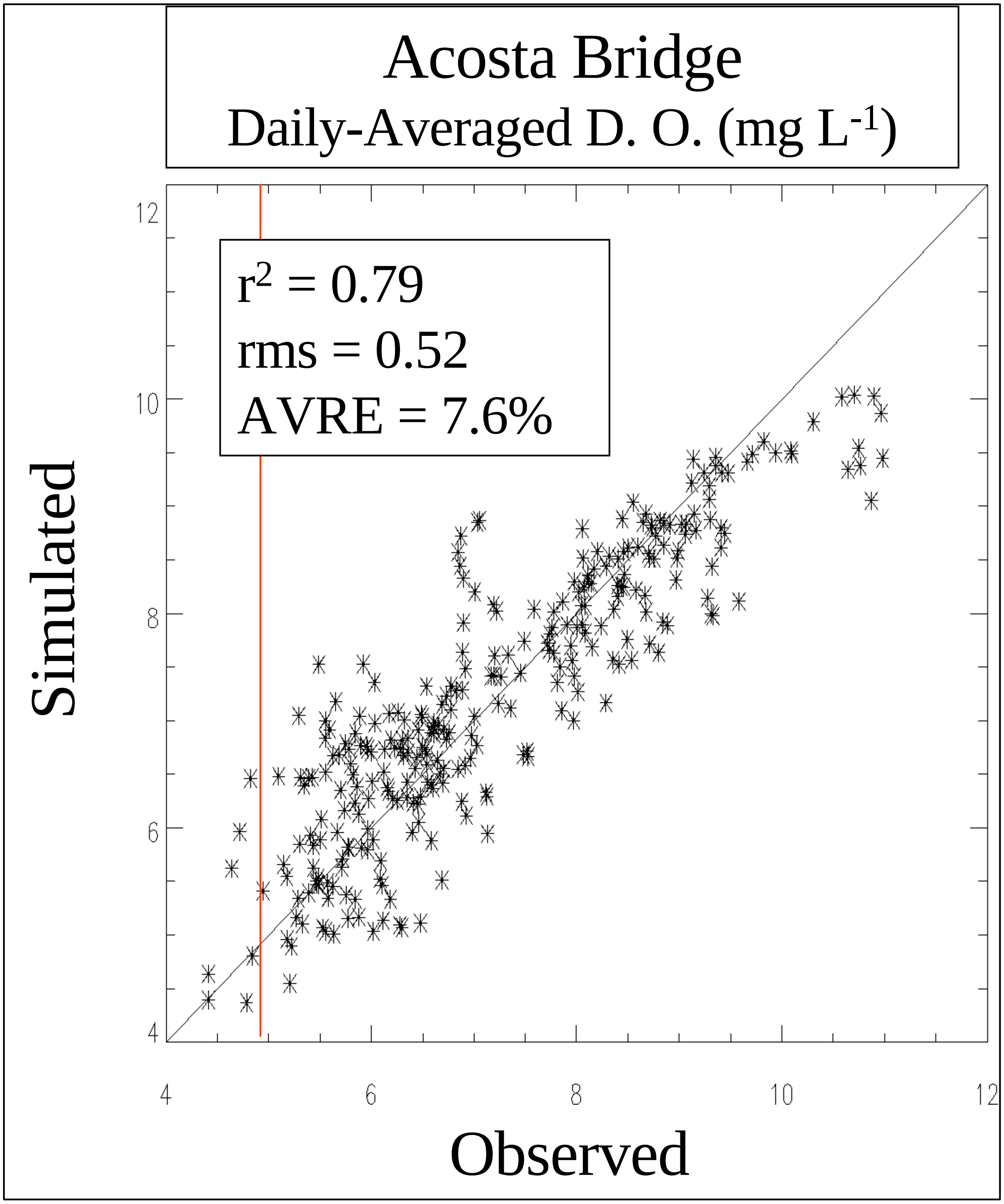


Figure F1. Accuracy of Model DO Predictions for Acosta Bridge

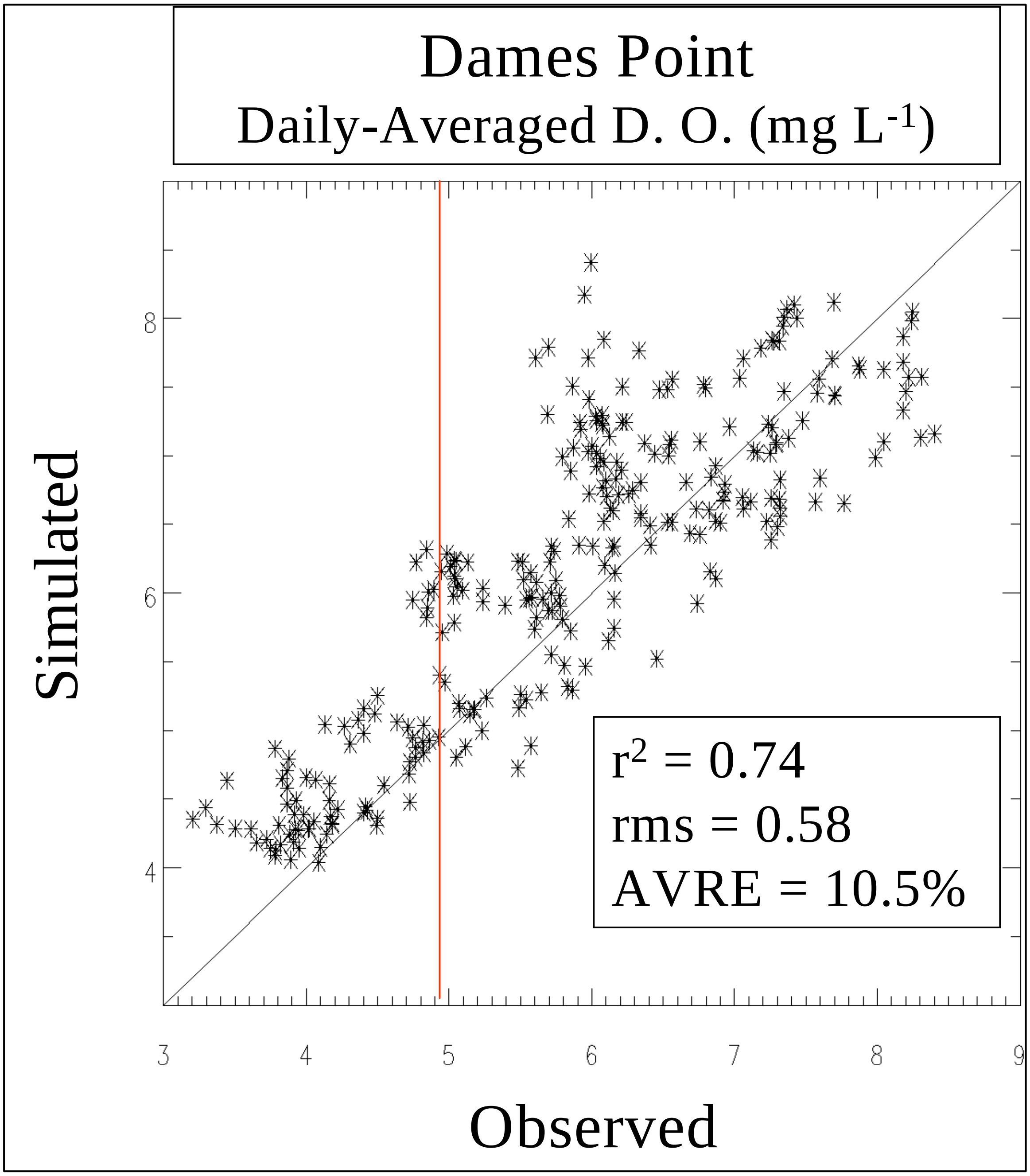


Figure F2. Accuracy of Model DO Predictions for Dames Point

APPENDIX G
EXAMPLE OF CHLOROPHYLL *A* CALIBRATION FIGURES FOR THE WATER QUALITY MODEL

Figure G1. Comparisons of Model Predictions Versus Measured Values for Chlorophyll *a* at Racy Point

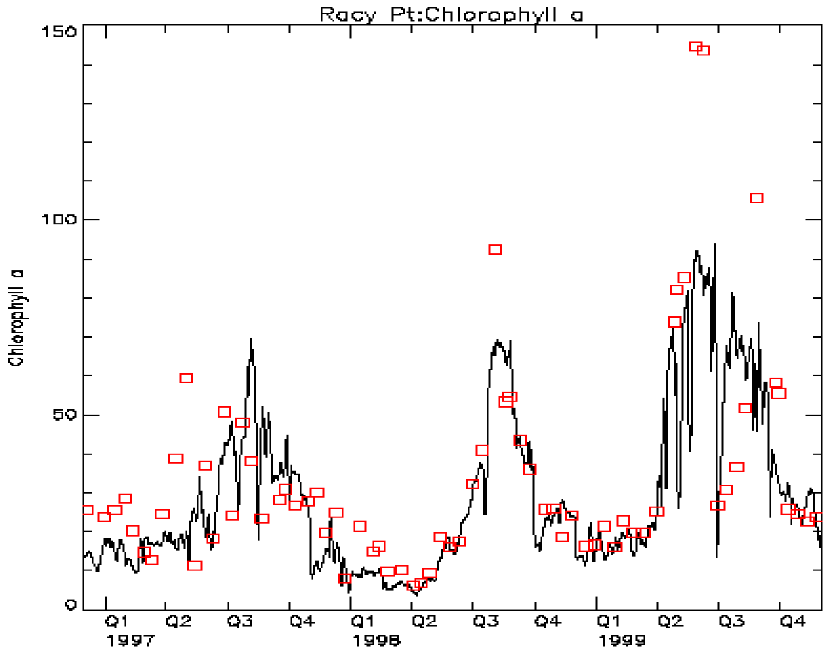


Figure G2. Comparisons of Model Predictions Versus Measured Values for Chlorophyll a at Watson Island

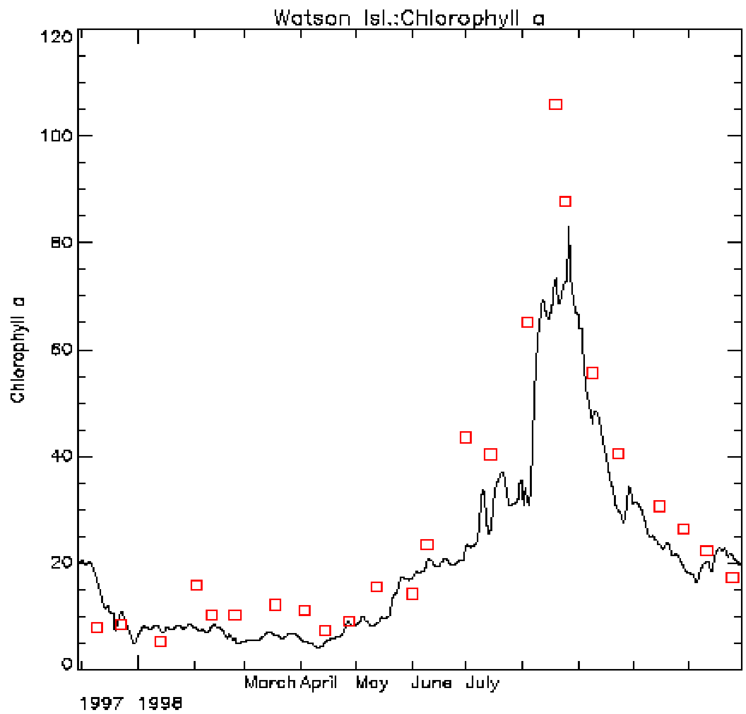


Figure G3. Accuracy of Model Predictions of Average Annual Chlorophyll a for the Freshwater Section

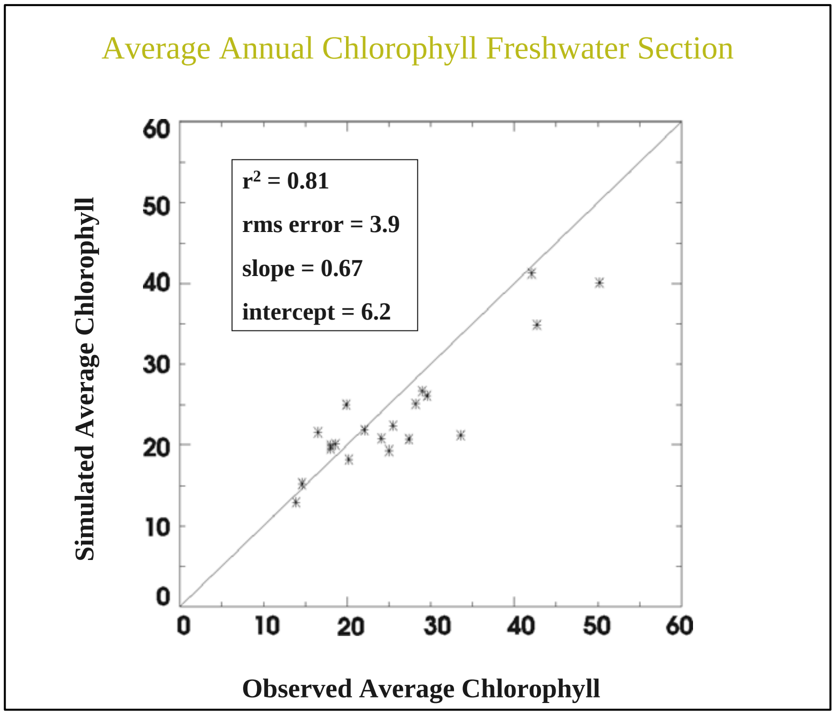
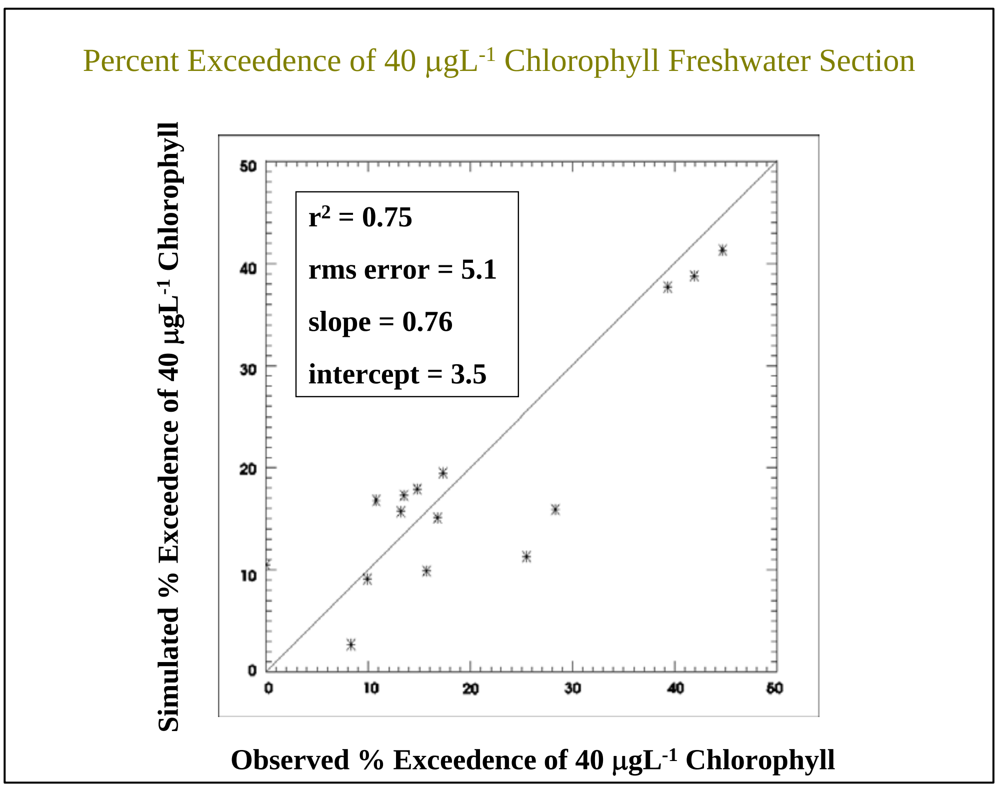


Figure G4. Accuracy of Model Predictions for Chlorophyll a Percent Exceedances for the Freshwater Section



APPENDIX H
RESPONSIVENESS SUMMARY TO PUBLIC COMMENTS ON DRAFT FDEP TMDL (PREVIOUSLY SUBMITTED TO EPA)

Responsiveness Summary for
the Proposed Nutrient TMDL for the Lower St. Johns River

The agency noticed the proposed TMDL via an e-mail to interested parties on October 1, 2007. The e-mail provided a URL link to the TMDL, provided the address for people to provide comments, and noted that the comment period extended through November 30, 2007. Written comments were received from the City of Jacksonville, the Jacksonville Electric Authority (JEA), Putnam County, Georgia-Pacific, the Florida Pulp and Paper Association, the LSJR TMDL Executive Committee, and the Florida Department of Environmental Protection (DEP). Comments and the agency's response have been organized by topic.

Daily Expression of the TMDL

The majority of the comments received addressed the daily expression of the TMDL. Several parties requested that EPA use a more technically rigorous methodology to calculate the daily expression, while other parties requested further clarification about the regulatory significance of the daily expression. Others commented that the TMDL should be consistent with EPA's November 2006 and June 2007 memoranda about the expression and application of daily loads, and requested specific revisions to the document as follows:

1) Add the following text to page 29 (after the paragraph referencing the TMDLs in Tables 5 and 6):

   As described in the note for Tables 5 and 6, a daily expression of the TMDLs can be calculated by dividing the annual average load by 365.25. The resultant loads represent the total maximum annual average daily loads. However, the TMDLs to be implemented are those expressed on a mass per year basis, and the expression of the TMDL on a mass per day basis is for information purposes only.

2) In concert with this addition, the note for Tables 5 and 6 should be revised as follows:

   To calculate the total maximum annual average daily load that should be expected divide the annual average load by 365.25.

3) Add text to Section 6.3 (Wasteload Allocations) clarifying that the effluent limits in NPDES permits will be based on the annual expression of the TMDL, and add a reference to EPA's November 2006 memorandum, noting that the Friends decision does not effect an NPDES permitting authority's ability to use its discretion under the CWS and NPDES regulations in establishing effluent limits.

RESPONSE: EPA certainly agrees that the TMDL should be consistent with EPA guidance memos relating to the expression and application of TMDLs expressed as daily loads. While the original TMDL was consistent with EPA guidance, EPA agrees with the suggested revisions, which will serve to clarify the agency's position on this issue. Staff has revised the document consistent with the requested revisions, including changing the daily expression to the "total maximum annual average daily load".

Request to Finalize the TMDL as Soon as Practicable

In addition to requesting EPA to carefully consider comments from the City of Jacksonville and the LSJR TMDL Executive Committee, JEA requested EPA finalize the TMDL as soon as practicable.

RESPONSE: We certainly share the goal of wanting to finalize the TMDL as soon as practicable to support the State's implementation of the TMDL, and have moved expeditiously to review and address all comments received, in preparation for finalizing the TMDL.

Comments from the Department of Environmental Protection TDML Program

In addition to commenting about the daily expression of the TMDL, DEP's TMDL Program also noted that they are continuing to work with stakeholders to refine the allocation and requested that EPA contact DEP to obtain the most recent allocation spreadsheets. DEP also noted several minor inconsistencies in the document text.

RESPONSE: EPA revised the document to address the specific issues raised and coordinated with Dr. Magley to ensure that the final document reflects the most up-to-date allocation.

Comments from the Department of Environmental Protection NPDES Stormwater Section

DEP's NPDES Stormwater Section also provided comments on the LSJR TMDL. The comments requested that EPA update language in Appendix A, which provides background information about Federal and State stormwater programs, and text in Section 6.2.3, which describes the MS4 permitting program. However, the section reference was incorrect (it should have been Section 4.3.3) and the proposed text inadvertently included some text that was applicable to a different TMDL.

RESPONSE: EPA updated the applicable text in both the Appendix and Section 4.3.3.

APPENDIX I
ANNUAL AVERAGE CHLOROPHYLL *a* VALUES AND TSIs FOR THE LSJR MAIN STEM

WBID	Water Segment Name	CHLA or TSI[1]	Annual Average Chlorophyll or TSI for Given Year					
			1996	1997	1998	1999	2000	2001
2213A	STJ RIV AB MOUTH	CHLA[3]	NA[2]	NA	NA	NA	4.42	4.67
2213B	STJ RIV AB ICWW	CHLA[3]	4.65	3.52	10.31	8.40	7.21	9.79
2213C	STJ RIV AB DAMES PT	CHLA[3]	4.35	3.61	NA	6.12	4.54	7.89
2213E	STJ RIV AB WARREN BRG	CHLA	9.02	12.31	14.98	12.0	9.21	8.55
2213F	STJ RIV AB PINEY PT	CHLA	7.50	NA	14.89	9.31	12.55	6.16
2213I	STJ RIV AB BLACK CK	TSI	61.4	61.5	62.6	58.6	56.2	57.8
2213J	STJ RIV AB PALMO CK	TSI	63.6	63.0	64.1	61.6	56.3	59.7
2213K	STJ RIV AB TOCIO	TSI	66.0	64.6	64.5	66.0	63.4	63.9
2213L	STJ RIV AB FEDERAL PT	TSI	65.4	63.6	62.2	64.7	60.9	60.4
2213M	STJ RIV AB RICE CK	CHLA	31.14	30.06	25.09	37.79	25.07	25.23
2213N	STJ RIV AB DUNNS CK	CHLA	34.04	31.81	21.30	31.42	24.40	NA

[1] Chlorophyll in υg/L and TSI unitless.
[2] NA = Not available.
[3] Listed based on increase over historical levels.

APPENDIX J
ALLOCATION SPREADSHEETS FOR THE FRESHWATER AND ESTUARINE PORTIONS OF THE LSJR

Wasteload and Load Allocations for Fresh Water Portion of River - Total Phosphorus

Source Category or Name of Facility	Wasteload Allocation (kg/year)	Required Percent Reduction
Point Sources - Wastewater		
GEORGIA-PACIFIC	33181.8	NA
PALATKA WWTF	6669.5	NA
Green Cove Springs - Harbor[1]	1851.5	NA
Green Cove Springs - South[1]	545.2	NA
Future Apricot/RO Dischargers	3320.1	NA
Point Sources - MS4s[2]		
Green Cove Springs[1]	575.9	47.44%
Clay County	212.6	47.44%
Load Allocations[2]		
Agriculture	70974.2	14.96%
Non-MS4 Stormwater[2]		
Putnam County	3964.9	33.81%
Palatka	792.5	47.44%
St. Johns Co.	3296.6	11.56%
Clay Co. non-MS4	499.4	34.92%
Welaka	90.4	47.44%
Hastings	49.3	46.93%
Pomona Park	15.8	0.00%
Alachua County	83.8	0.00%
Flagler Co.	0.9	0.00%
Atm Deposition	1355.9	0.00%

[1] Green Cove Springs has requested their MS4 and wastewater loads be aggregated into one WLA, which would be 2,972.6 kg/yr.

[2] Loads shown for MS4s and Non-MS4s are provided only for purposes of pollutant trading and aggregation of loads. The allocations are expressed in percent reduction.

Fresh Water Portion of River Nitrogen kg/yr Average of 95,97,98,99

Source Category or Name of Facility	Allocation	Net Reduction from Current
Point Sources - Wastewater		
GEORGIA-PACIFIC	165909.1	35.73%
PALATKA WWTF	40795.4	33.00%
GCS Harbor[1]	5863.2	38.00%
GCS South[1]	3188.8	38.00%
SEMINOLE ELECTRIC	4006.7	30.00%
Future Apricot/RO Dischargers	9960.5	0.00%
Point Sources - MS4s[2]		
Green Cove Springs[1]	4986.6	28.37%
Clay County	1984.2	28.37%
Load Allocations[2]		
Agriculture	195120.2	37.20%
Non-MS4 Stormwater[2]		
Putnam County	34113.4	21.79%
St. Johns Co.	25442.2	6.73%
Palatka	6936.1	28.37%
Clay Co. non-UA	4418.5	20.80%
Welaka	841.4	28.37%
Hastings	449.4	28.03%
Alachua Co. non-UA	0.0	0.00%
Pomona Park	107.9	0.00%
Flagler Co. non-UA	6.9	0.00%
Atm Deposition	105688.2	0.00%

[1] Green Cove Springs has requested their MS4 and wastewater loads be aggregated into one WLA which would be 14,038.6 kg/yr.

[2] Loads shown for MS4s and Non-MS4s are provided only for purposes of pollutant trading and aggregation of loads. The allocations are expressed in percent reduction.

Source Category or Name of Facility	Allocation	Net Reduction from Start Point
Point Sources - Marine Wastewater		
An Busch - Mn St	12413.4	49.12%
Atl Beach - Buccanneer[2]	8428.5	60.00%
Atl Beach - Main[2]	13425.9	52.40%
CCUA - Fleming Island[4]	43820.5	-53.56%
CCUA - Fleming Oaks[4]	2983.5	-78.05%
CCUA - Miller St[4]	37219.5	-18.70%
Jax Beach WWTF[1]	23868.2	40.55%
JEA - Arlington[3]	134258.7	62.24%
JEA - Beacon Hiils[3]	7384.2	55.04%
JEA - Brierwood SD[3]	0.0	0.00%
JEA - Buckman[3]	253748.9	48.43%
JEA - District II[3]	40277.6	76.11%
JEA - Holly Oaks[3]	0.0	0.00%
JEA - Jax Heights[3]	12083.3	46.45%
JEA - Jul Crk[3]	3550.4	55.42%
JEA - Mandarin[3]	52211.7	-0.87%
JEA - Monterey[3]	26851.7	52.54%
JEA - Ortega Hills[3]	0.0	0.00%
JEA - Royal Lakes[3]	22301.9	30.35%
JEA - San Jose[3]	16782.3	46.19%
JEA - San Pablo[3]	5594.1	15.71%
JEA - St. Johns North[3]	0.0	0.00%
JEA - SW[3]	74588.1	48.62%
JEA - Woodmere[3]	4773.6	52.83%
Neptune Beach WWTF[5]	7011.3	38.75%
Orange Park WWTF[6]	9994.8	59.84%
Smurfit - Jax	0.0	0.00%
Smurfit-Stone Container	74274.6	49.12%
USN - Mayport WWTF[7]	7682.6	44.94%
USN - NAS Jax WWTF[7]	8428.5	36.50%
Westminster Woods	0.0	0.00%
Future Apricot/RO Dischargers	4979.3	0.00%
JEA Total	654406.5	53.14%
CCUA - Total	84023.5	-36.47%
Point Sources - MS4s[8]		
Atlantic Beach	975.4	60.57%
Clay_marine_UA	10551.8	58.21%
NAS Jax	1769.1	62.86%
Jacksonville,City	95977.0	60.57%
Jax Beach	1940.0	61.00%
SJ Co	4537.3	56.82%
Orange Park	1288.9	62.65%
Mayport UA	1027.9	62.85%
Neptune Beach	585.2	60.57%

Source Category or Name of Facility	**Allocation**	**Net Reduction from Start Point**
Point Sources - Marine Wastewater		
Load Allocations[8]		
Agriculture	4167.8	67.44%
Non-MS4 Stormwater[8]		
Clay_marine_nonUA	4973.4	58.73%
Camp Blanding	1572.8	58.61%
SJC remaining marine	1060.1	55.29%
Penney Farms	163.0	0.00%
Atm Dep - Marine	95028.1	0.00%

[1] Jacksonville Beach requested that their MS4 and wastewater loads be aggregated into one WLA which would be 25,808.2 kg/yr .

[2] Atlantic Beach requested that their wastewater loads be aggregated into one WLA which would be 22,829.7 kg/yr.

[3] JEA requested that all their wastewater allocations be aggregated into one WLA which would be 654,406.5 kg/yr.

[4] Clay County Utilities Authority requested that their wastewater allocations be aggregated into one WLA which would be 84,023.5 kg/yr.

[5] Neptune Beach requested that their wastewater allocations be aggregated into one WLA which would be 7,596.5 kg/yr.

[6] Orange Park requested that their wastewater allocations be aggregated into one WLA which would be 11,283.8 kg/yr.

[7] The United States Navy requested that their wastewater allocations be aggregated into one WLA which would be 18,908.0 kg/yr.

[8] Loads shown for MS4s and Non-MS4s are provided only for purposes of pollutant trading and aggregation of loads. The allocations are expressed in percent reduction.

Source Category or Name of Facility	**Allocation**	**Net Reduction from Start Point**
Point Sources - Marine Wastewater		
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[8] Loads shown for MS4s and Non-MS4s are provided only for purposes of pollutant trading and aggregation of loads. The allocations are expressed in percent reduction.

APPENDIX K
ONGOING AND PROPOSED STUDIES BY THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT DESIGNGED TO REVISE THE TMDL TO ADDRESS SUBMERGED AQUATIC VEGETATION AND FURTHER EVALUATE NUTRIENT IMPACTS

St. Johns River Water Management District Lower St. Johns Projects

1. The SJRWMD recently amended their contract with the USACOE/WES to add money to complete necessary code changes in the submerged aquatic vegetation (SAV) components of CE-QUAL-ICM, improve model simulation speed by parallel processing of grids, and set up a sigma grid option. The contract is scheduled to be completed by the end of the year (2004).

2. Dr. Carl Gallegos is completing further work on his light model for the St. Johns by addressing salinity influences. A final report is due at the end of the year (2004).

3. Dr. Hans Paerl has one more year of field studies to complete his three-year study on nitrogen fixation in the Lower St. Johns River. This summer, he will conduct monthly surveys and 3 one-week assays. A final report is due next March (2005).

4. Funding for Dr. Ed Philps phytoplankton and zooplankton sampling has been extended for two more years. He will be conducting some studies in conjunction with Dr. Paerl this summer.

5. The SAV project with the USGS lab in Louisiana has been completed and final reports should be available this summer (2004). Information obtained through those studies will be used in the CE-QUAL-ICM model.

6. A recent contract has been signed with researchers at the University of Alabama to study the export and degradation of terrestrially derived organic material in the Lower St. Johns River.

7. An ongoing project that has evaluated sediment fluxes and denitrification rates will continue through the fall and will involve monthly sampling during this summer. Results of this work will be used to review rates that were used in the model to establish the TMDL.

This list summarizes some of the key projects. It is not intended to identify all of the ongoing projects and programs that are part of the SJRWMD activities in the Lower St. Johns River and it's designation as a SWIM water at the state level or an American Heritage River at the federal level.

APPENDIX L
SITE SPECIFIC ALTERNATIVE DISSOLVED OXYGEN CRITERION DOCUMENTATION

Site Specific Alternative Dissolved Oxygen Criterion to Protect Aquatic Life in the Marine Portions of the Lower St. Johns River Technical Support Document

April 28, 2006

Prepared by:

Florida Department of Environmental Protection
Tallahassee, FL
&
St. Johns River Water Management District
Palatka, FL

For Submittal to:

U.S. Environmental Protection Agency

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INTRODUCTION

The purpose of this report is to provide the technical basis for establishing Site Specific Alternative Criteria (SSAC) for dissolved oxygen (DO) for the protection of aquatic life in the predominately marine portions of the Lower St. John's River (LSJR) between Julington Creek and the mouth of the river. The SSAC for DO in the LSJR presented herein was developed in accordance with the procedures set forth in subsection 62-302.800(2), Florida Administrative Code, for Type II Site Specific Alternative Criteria. The proposed DO SSAC was derived by the Florida Department of Environmental Protection (FDEP) and the St. John River Water Management District (SJRWMD) based on an application of the methodology developed by the U.S. Environmental Protection Agency (EPA) for the Virginian Province (EPA 2000). As described below, EPA's Virginian Province approach uses knowledge regarding the biological response of sensitive aquatic organisms to hypoxic stressors to derive DO criterion that provide adequate protection from acute and chronic effects of exposure to low DO levels in marine waters.

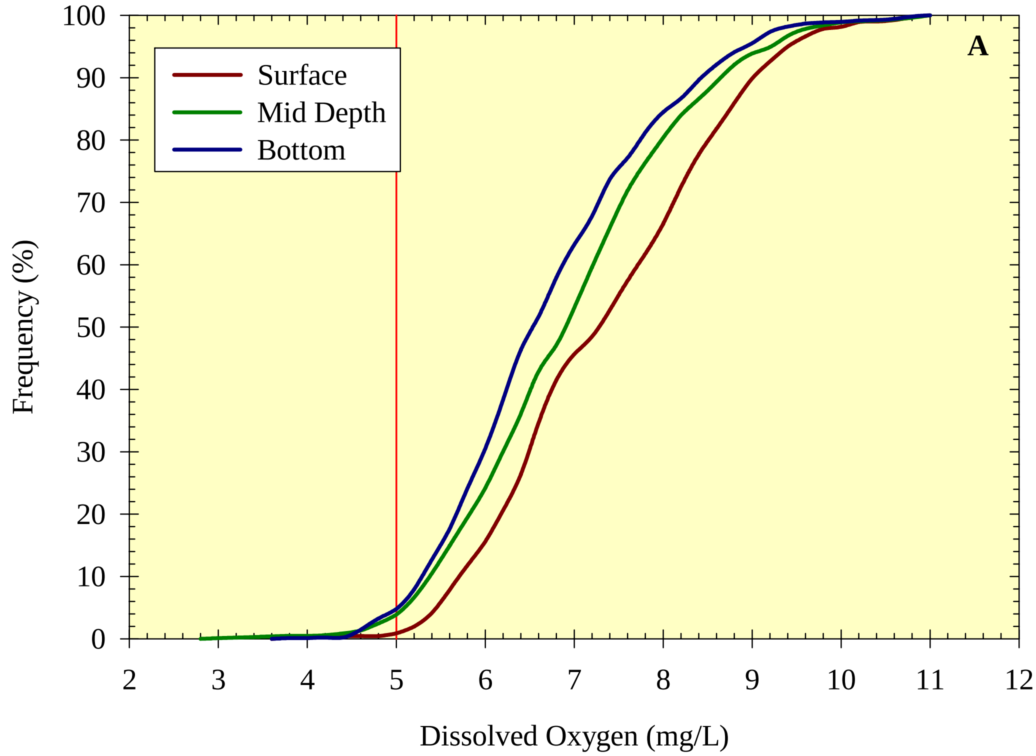
Description of Existing Conditions

Persistent, low (below 5 mg/L) concentrations of dissolved oxygen in the meso/polyhaline reach of the LSJR are well documented but poorly understood phenomena (Hendrickson, et al. 2003). The incidences of low dissolved oxygen conditions occur simultaneous with high summertime temperatures, and appear to be associated with the decline of significant algal blooms. The U.S. Geological Survey has established continuous monitoring stations within the marine reach of the LSJR at Dames Point and the Acosta Bridge (**Figure 1**). Monitoring data from these two stations are available for the period from 1996 through 2001 and are summarized in **Table 1**. For the period of record, dissolved oxygen levels were below 5 mg/L for 0.5, 2.7, and 3.9 % percent of the time, in the surface, mid depth waters, and bottom, respectively, at the Acosta Bridge Station (**Figure 2**). Further downstream at the Dames Point site, DO concentrations were below 5.0 mg/L for 15% of the time at the surface, 22% of the time at mid depth, and 35% of the time at the bottom during the same period.

Table 1. Summary statistics for daily dissolved oxygen concentrations (mg/L) measured at USGS automated monitoring stations at Acosta Bridge and Dames Point between 1996 and 2001.

Station	Depth	N	Mean	Median	Std Dev.	Minimum	25th Percentile	75th Percentile	Maximum
Acosta Bridge	Surface	918	7.4	7.3	1.27	3.7	6.4	8.3	11.0
	Middle	1059	7.0	6.9	1.26	2.9	6.1	7.8	11.0
	Bottom	1049	6.8	6.6	1.21	3.7	5.9	7.6	10.9
Dames Point	Surface	839	6.2	5.9	1.21	3.7	5.3	7.1	9.5
	Middle	808	5.8	5.6	1.19	3.2	5.0	6.5	9.2
	Bottom	707	5.6	5.4	1.11	3.4	4.7	6.3	9.0

Figure 1. USGS water quality monitoring stations in the estuarine reach of the Lower St. Johns River.



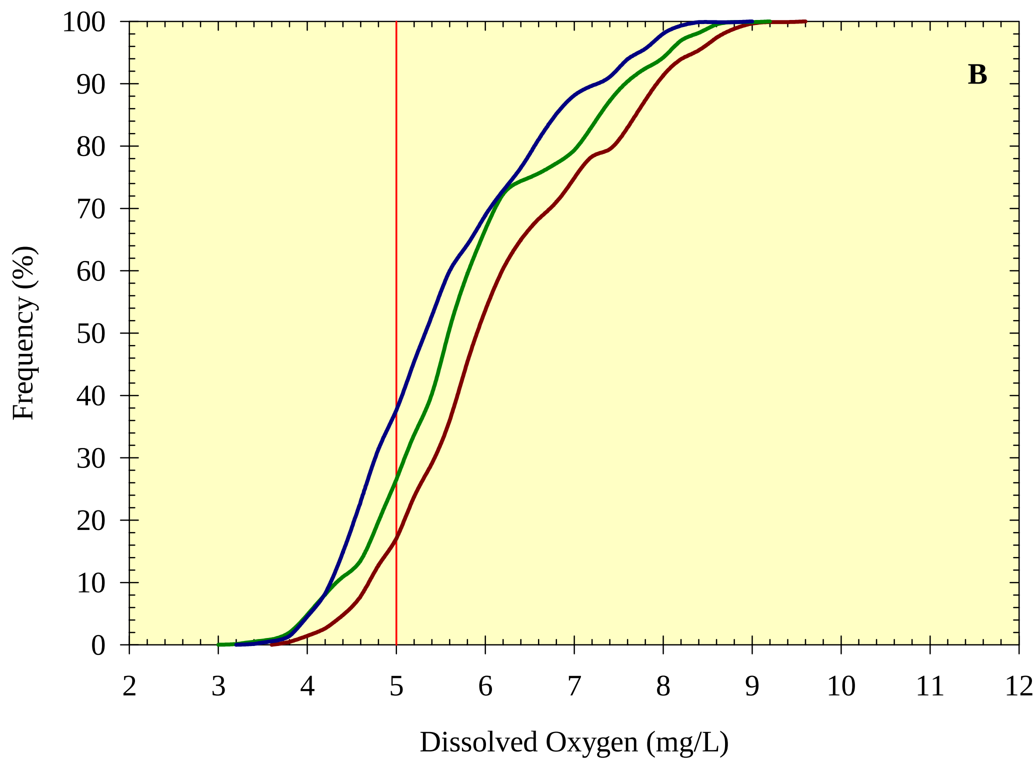


Figure 2. Cumulative DO frequency distribution at the USGS (A) Acosta Bridge and (B) Dames Point stations from 1996 through 2001. The red vertical line indicates the current one day average Class III marine criteria of 5.0 mg/L.

OVERVIEW OF THE EPA VIRGINIAN PROVINCE DO CRITERIA APPROACH

The EPA Virginian Province document (EPA 2000) recommends an approach for deriving dissolved oxygen levels necessary to protect coastal and estuarine organisms in the Virginian Province. The document also provides guidance regarding the application of the recommended methodology to other coastal or estuarine systems. The proposed DO SSAC presented herein was derived based on an application of the methodology developed by the U.S. Environmental Protection Agency (EPA) for the Virginian Province (EPA 2000) to the Lower St. Johns River.

The EPA Virginian Province methodology represents a synthesis of current knowledge regarding biological responses to hypoxic stressors in aquatic ecosystems. This approach considers the response to both continuous and cyclic exposures to low DO levels in the derivation of criteria which are protective of aquatic life. The aquatic life based approach utilized for the Virginian Province (EPA 2000) identifies three important DO concentration levels as follows:

- The Criterion Continuous Concentration (CCC), which is defined as a mean daily DO concentration above which continuous exposure is not expected to result in unacceptable biological effects.
- The Criterion Minimum Concentration (CMC), which is defined as a daily DO concentration below which any exposure for a 24-hour period would result in unacceptable acute effects (mortality). The CMC applies a lower limit for continuous exposures by using the final acute value (FAV) calculations outlined in Stephen *et. al*. (1985).
- A set of mean daily DO concentrations between the CCC and CMC that identify conditions that may be tolerated for specific limited durations as defined by the Final Recruitment Curve (FRC).

Aquatic life and its uses are assumed to be fully supported as long as DO conditions remain at or above the (CCC) chronic criterion for growth (EPA value = 4.8 mg/L). Conversely, if DO conditions fall below the juvenile/adult survival criterion (CMC) of 2.3 mg/L (EPA value), there is insufficient DO to prevent unacceptable effects to aquatic life. When DO conditions are between these two values (2.3 to 4.8 mg/L), further evaluation of the duration and intensity of low DO is needed to determine whether the level of oxygen can support a healthy aquatic life community (EPA 2000). This evaluation is conducted via comparison between monitored data and the FRC. To derive the CCC, CMC, and FRC, the EPA Virginian Province method utilizes biological responses of sensitive species during various life stages to low DO concentrations as briefly summarized below.

Juvenile and Adult Survival

Data regarding the acute sensitivity of juvenile and adult saltwater organisms to continuous low DO exposures ranging from 24 to 96 hours were used to derive the Criterion Minimum Concentration (CMC) in EPA's Virginian Province method. Acute response data were available for 12 invertebrate and 11 fish species (**Table 2**). 15 of the 23 species used by EPA for the

Virginian Province are also known to inhabit estuarine waters of northeast Florida based on sampling and expert knowledge (Hendrickson, et al., 2005; FMRI 2002; CSA, Inc., 1993; Frydenborg 2005). The species known to be indigenous in Florida generally span the range of acute DO sensitivities and include the most sensitive species (pipe fish, *Syngnathus fuscus*) used by EPA (**Table 2**).

EPA calculated the criteria for exposure to continuous low DO by using a modified version of the procedure for the derivation of a final acute value (FAV) for toxicants presented in Stephen *et al*., (1985). The standard procedure was modified to account for the fact that organisms respond to DO in an opposite manner than that to toxicants; that is, the greatest negative response is low levels rather than high levels. The FAV for the Virginian Province was calculated to be 1.64 mg/L, which is the value representative of the LC50 for the 95th percentile genus (as ranked in order of sensitivity to low DO levels). The FAV was then adjusted to a CMC of 2.27 mg/L by multiplying by the average LC5 to LC50 ratio (1.38) for juveniles. Similarly, a CMC of 2.3 mg/L was derived by Hendrickson *et al.,* (2003) based on a calculation performed using the 12 species known to inhabit the study area and based upon the FAV for the most sensitive species (pipe fish).

Growth

To protect against sub-acute effects, the Virginian Province DO criteria also included an evaluation of the effect of low DO levels on marine organism growth. EPA (2000) noted that growth is generally more sensitive to low DO than survival, although the document does mention exceptions for *Menidia menidia* and *Dyspanopeus sayi* where survival was the more sensitive endpoint in some tests.

EPA (2000) evaluated data on the effects of low DO on the growth of 11 species (4 fish and 7 invertebrates) from a total of 36 tests. Geometric mean chronic values (GMCV) for the 11 species ranged from 1.97 mg/L (sheepshead minnow,*Cyprinodon variegatus*) to 4.67 mg/L (longnose spider crab, *Libinia dubia*). A DO level protective of growth was determined to be 4.8 mg/L, which represented the chronic value that would not result in a greater than 25 percent reduction in growth in species at the 95th percentile of the values for sensitive species represented. Long-term, continuous exposures at or above this level should not cause unacceptable effects to marine organisms.

Larval Recruitment

U.S. EPA (2000) developed a generic model to evaluate the cumulative effect of low DO on early life stages of aquatic animals. This model was used to estimate the effects of DO concentrations between the acute value (CMC) of 2.3 mg/L and the CCC (4.8 mg/L). The model used for the Virginian Province estimates the duration a DO concentration can be tolerated without causing unacceptable effects on larval recruitment, defined as greater than 5% reduction in larval recruitment during the entire recruitment season. A final recruitment curve (FRC) was developed between the CCC and CMC.

The FRC was fit using the larval dose-response curves from the four most sensitive genera (*Morone, Homarus, Dyspanopeus*, and *Eurypanopeus*). The equation for the FRC was derived by fitting the line of best fit through the points generated by output of the recruitment model (**Figure 2**). The equation for the FRC is given as:

where: $P(t)$ = the DO concentration at time t
P_0 = the y-intercept
L = the upper DO limit
k = a rate constant, and
t = time in days, the number of days over which $P(t)$ may be tolerated

EPA (2000) and Thursby (2003) suggested that the FRC developed for the Virginian Province may be overprotective for areas to the south. This is due to the fact that recruitment seasons lengthen and larval development times decrease, with increased distance south from the Virginian Province. Both factors would act to decrease the sensitivity of the FRC and shift

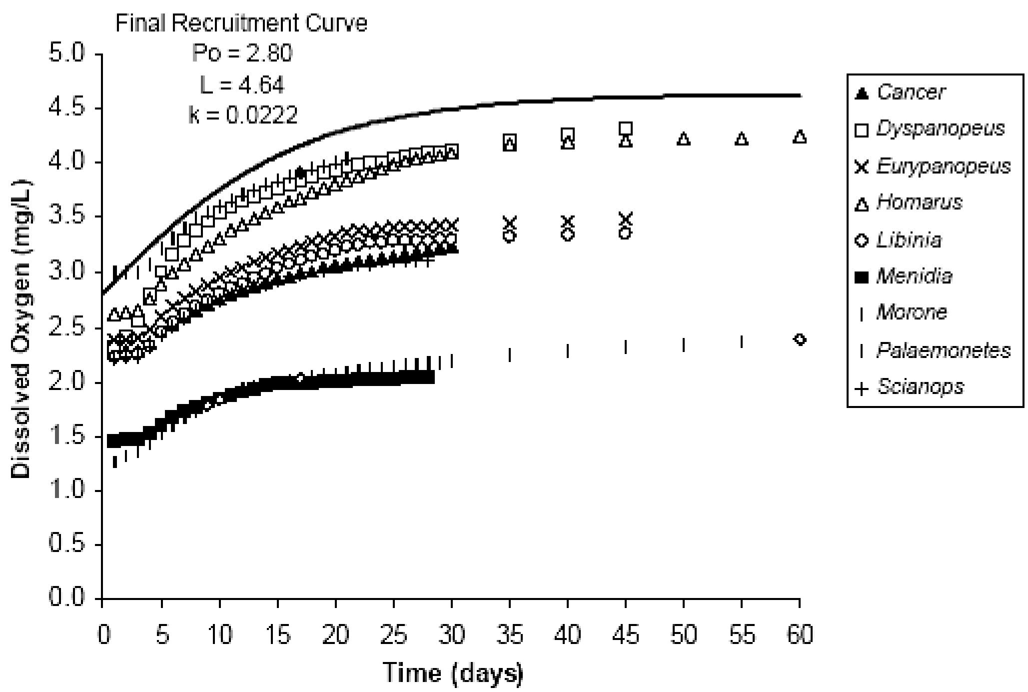


Figure 2. Plot of model outputs that protect against greater than a 5% cumulative impairment of larval recruitment. The solid line is regression of best fit for the FRC based on the 4 most sensitive species. Figure taken from EPA (2000).

the curve in **Figure 2** down and to the right.

$$\mathbf{P(t)} = \frac{\mathbf{P_0 L}}{\mathbf{P_0 + e^{-Lkt}(L - P_0)}}$$

Table 2. Acute sensitivity of juvenile and adult saltwater animals to low dissolved oxygen. Exposure durations ranged from 24 to 96 hr. (Recreated from EPA 2000). Highlighted species are known to be indigenous to the St. Johns River.

Species	Common Name	Life Stage	SMAV LC50[a]	SMAV LC5	SMAV LC5/LC50	GMAV LC50	GMAV LC50[a]	GMAV LC5	GMAV LC5/LC50	GMAV Rank[b]
Carcinus maenus	Green Crab	Juvenile/Adult	<0.34			<0.34	0.34			1
Spisula solidissima	Atlantic Surf Clam	Juvenile	0.43	0.7	1.63	0.43	0.43	0.70	1.63	2
Rithropanopeus harrisii	Harris Mud Crab	Juvenile	0.51			0.51	0.51			3
Prionotus carolinus	Northern Sea Robin	Juvenile	0.55	0.8	1.45	0.55	0.55	0.80	1.45	4
Eurypanopeus depressus	Flat Mud Crab	Juvenile	0.57			0.57	0.57			5
Leiostomus xanthurus	Spot	Juvenile	0.7	0.81	1.16	0.7	0.7	0.81	1.16	6
Tautoga onitis	Tautog	Juvenile	0.82	1.15	1.40	0.82	0.82	1.15	1.40	7
Palaemonetes vulgaris	Marsh Grass Shrimp	Juvenile	1.02	1.4	1.37	0.86	0.86	1.24	1.44	8
Palaemonetes pugio	Daggerblade Grass Shrimp	Juvenile	0.72	1.1	1.53					
Ampelisca abdita	Amphipod	Juvenile	<0.9			<0.9	0.9			9
Scopthalmus aquosus	Windowpane Flounder	Juvenile	0.81	1.2	1.48	0.9	0.9	1.20	1.33	10
Apeltes quadracus	Fourspine Stickleback	Juvenile/Adult	0.91	1.2	1.32	0.91	0.91	1.20	1.32	11
Homarus americanus	American Lobster	Juvenile	0.91	1.6	1.76	0.91	0.91	1.60	1.76	12
Crangon septemspinosa	Sand Shrimp	Juvenile/Adult	0.97	1.6	1.65	0.97	0.97	1.60	1.65	13
Callinectes sapidus	Blue Crab	Adult	<1.0			<1.0	1			14
Brevoortia tyrannus	Atlantic Menhaden	Juvenile	1.12	1.72	1.54	1.12	1.12	1.72	1.54	15
Crassostrea virginica	Eastern Oyster	Juvenile	<1.15			<1.15	1.15			16
Stenotomus chrysops	Scup	Juvenile	1.25			1.25	1.25			17
Americamysis bahia	Mysid	Juvenile	1.27	1.5	1.18	1.27	1.27	1.50	1.18	18
Paralichthys dentatus	Summer Flounder	Juvenile	1.32	1.57	1.19	1.32	1.32	1.57	1.19	19
Pleuronectes americanus	Winter Flounder	Juvenile	1.38	1.65	1.20	1.38	1.38	1.65	1.20	20
Morone saxatilis	Striped Bass	Juvenile	1.58	1.95	1.23	1.58	1.58	1.95	1.23	21
Syngnathus fuscus	Pipe Fish	Juvenile	1.63	1.9	1.17	1.63	1.63	1.90	1.17	22

[a] SMAVs (Species Mean Acute Values) and GMAVs (Genus Mean Acute Values) mg/L Final Acute Value = 1.64

are all geometric mean values (Stephen et al, 1985)

[b] Ranked according to LC50 GMAV values

Mean LC5/LC50 Ration =	1.38 mg/L
CMC = 1.64 mg/L x 1.38 =	2.27 mg/L

Application of the Marine Criteria Approach

The final marine DO criteria for the Virginian Province are summarized in **Figure 3**. Below the survival level (CMC=2.3 mg/L), DO does not meet protective goals and designated uses are not maintained. At DO levels above the CCC growth level (4.8 mg/L) unacceptable effects from exposure to low DO levels are not expected and aquatic life and its uses are adequately protected. Evaluation of DO levels between the survival and chronic protection levels is based on the comparison between the FRC and measured cumulative DO exposure durations.

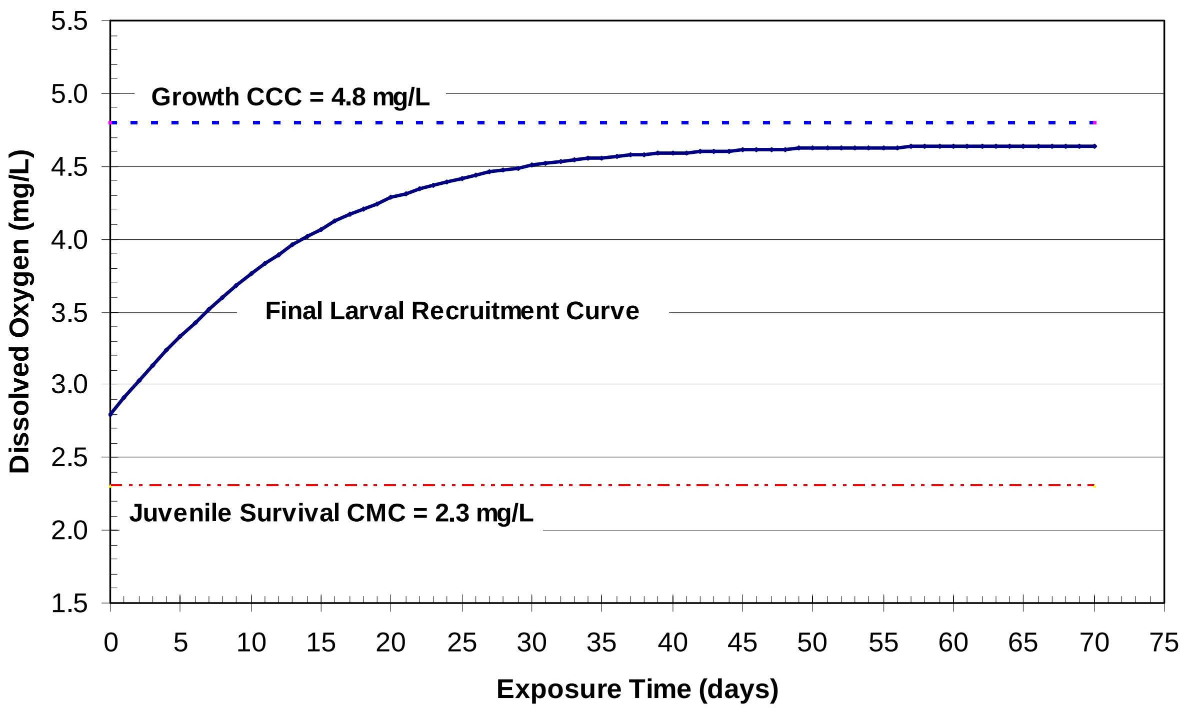


Figure 3. Plot of the final Virginian Province DO criteria for marine animals continuously exposed to low dissolved oxygen.

APPLICATION OF THE EPA VIRGINIAN PROVINCE APPROACH TO THE LSJR

The FDEP and SJWMD have evaluated the Virginian Province approach for deriving DO criteria for possible application in Florida's marine waters where the existing criteria may not be appropriate. Because the EPA's recommended approach for the Virginian Province is based on very conservative assumptions for northern cooler waters, it can be concluded that application of a similar approach to derive DO criteria for Florida's marine waters would provide a very conservative level of protection for aquatic life. In addition, many of the species used to derive the Virginian Province criteria are also known to occur in Florida waters including the LSJR with the species present in Florida waters generally bracketing the range of DO sensitivities seen in the entire complement of species used in EPA (2000). Therefore, the approach utilized by EPA to derive DO criteria for marine waters of the Virginian Province (EPA 2000) was used as the basis for the derivation of Site Specific DO Criteria that are protective of aquatic life in the saltwater portions of the Lower St. Johns River. While EPA's Virginian Province methodology provides the basis for the proposed SSAC for DO in the LSJR, the approach was modified slightly to take into account Florida's existing Class III marine criteria and existing conditions in the LSJR. The deviations from the EPA approach in developing the SSAC for DO in the LSJR are described below with a discussion regarding how the changes affect the level of protection afforded by the SSAC.

Based on the DO data collected from 1996 through 2001, only 0.2% of the daily average DO values measured at the Acosta Bridge site were below the current 4.0 mg/L minimum concentration in Florida's current marine DO criteria. Similarly, downstream at the Dames Point site less than approximately 2% of the daily average DO measurements were below 4.0 mg/L. While using the CMC (criterion minimum concentration) of 2.3 mg/L specified in the EPA Virginian Province for the LSJR would likely protect aquatic life from the acute effects of exposure to low DO levels, a CMC of 2.3 mg/L would allow minimum DO levels in the LSJR to be degraded from current conditions. Therefore, it is recommended that a CMC or minimum criterion of 4.0 mg/L be utilized for the LSJR instead of the 2.3 mg/L value recommended by EPA. By increasing the CMC to 4.0 mg/L, the level of protection afforded by the proposed SSAC would also be increased beyond that provided by the EPA recommended approach and is consistent with Florida's existing DO criteria for marine waters.

In addition, it is recommended that EPA's recommended CCC (criterion continuous concentration) of 4.8 mg/L be adjusted upward to 5.0 mg/L. In deriving the CCC, EPA "adjusted" the total number of species (i.e., "n") from the 11 species for which growth response data were available to the 22 species for which acute response data were available. Recalculating the CCC based on an "n" of 11, a value of approximately 5 mg/L is obtained. Additionally, the use of a 5.0 mg/L CCC instead of EPA's recommended 4.8 mg/L is consistent with the State's existing criteria and would provide a basis for requiring permitted discharges to continue to comply with 5.0 mg/L discharge limits currently in place. The use of 5.0 mg/L as the CCC would also afford a slightly increased level of protection compared to EPA's recommended value of 4.8 mg/L.

In the DO range between the CMC (4.0 mg/L) and the CCC (5.0 mg/L) the allowable duration within a portion of this range would be defined by the EPA's recommended Final Recruitment Curve (FRC) (EPA 2000 as shown in **Figure 3**). However, EPA's FRC plateaus at approximately 4.6 mg/L leaving the effect of exposure to DO concentrations in the interval between 4.6 mg/L and the CCC of 5.0 mg/L difficult to interpret. Since the EPA's FRC is based on the larval recruitment/survival of sensitive species, an additional component could be added to consider the **larval growth** response of sensitive species to interpret the effect of exposure to DO levels between the FRC and the CCC.

The proposed SSAC for DO in the LSJR utilizes the dose-response relationship between DO and growth of the most sensitive species identified by EPA (EPA 2000). In the documentation of the derivation of the DO criteria for the Virginian Province (EPA 2000), *Homarus americanus* (American lobster) is identified as the most sensitive species to low DO levels. As discussed previously, since species known to inhabit Florida waters generally bracket the range of sensitivities to low DO levels, it is not unreasonable to use data for the American lobster to represent an equally sensitive species that could potentially exist in the LSJR for which data does not exist. The use of the response of the American lobster in southern waters is also consistent with EPA guidance (EPA 2000). Additionally, using the single most sensitive species to develop the larval growth component of the SSAC would be very conservative and yield a criterion that is highly protective of all aquatic life.

As shown in **Figure 4,** using the data provided by EPA in the derivation of the Virginian Province DO criteria (EPA 2000), the lobster dose-response curve is approximated by a linear function:

$$\mathbf{G_{fr} = -0.231 * [DO] + 1.381} \qquad \textbf{(equation 1)}$$

where $\mathbf{G_{fr}}$ is the fractional reduction in growth rate below that of controls and **[DO]** is the dissolved oxygen concentration in mg/L. Using this function to determine the degree of growth reduction associated with a given **[DO]**, the impact on growth of a given duration of exposure to a range of concentration in DO can be estimated by another function:

$$\mathbf{R_{ygp} = T_e * G_{fr} / T_g} \qquad \textbf{(equation 2)}$$

where $\mathbf{R_{ygp}}$ is the fractional reduction of the year's larval and juvenile growth potential for the most sensitive species, $\mathbf{T_e}$ is the days of exposure within a specified range in concentration of dissolved oxygen, and $\mathbf{T_g}$ is the number of days within the year when larval and juvenile growth primarily occurs.

If equation 1 is then substituted for $\mathbf{G_{fr}}$ in equation 2 and equation 2 is then solved for $\mathbf{T_e}$, the resulting equation becomes:

$$\mathbf{T_e = -\frac{T_g * R_{ygp}}{0.231 * [DO] + 1.381}} \qquad \textbf{(equation 3)}$$

A value of 0.05 can be inserted for $\mathbf{R_{ygp}}$ to specify that no more than a 5% reduction in growth across the larval population on an annual basis is acceptable. Using a $\mathbf{R_{ygp}}$ value of 0.05 is consistent with acceptable level of impairment used by EPA in the derivation of the Virginian Province DO criteria. The annual number of days in which larval and juvenile growth of sensitive species can be expected to occur can be estimated using growth information available for sensitive species indigenous to the LSJR. The available information (Vernberg and Piyatirattivorakul, 1998; Tagatz, 1968) indicates that significant growth is inhibited at temperatures below 15°C and increases markedly between 15 and 20°C. Using the mid-point of this range, significant growth of the sensitive species in the LSJR can be considered to occur at temperatures of 17.5°C and above. Further, using the USGS monitoring data collected at the Acosta Bridge and Dames Point sites in the LSJR between 1996 and 2001, the annual number of days in which the water temperature is at or above 17.5 °C ranged from 261 to 291 with an average of 275 days being at or above 17.5°C.

Inserting the values of 0.05 for $\mathbf{R_{ygp}}$ and 275 for $\mathbf{T_g}$ into equation 3, the equation becomes:

$$\mathbf{Te} = -\frac{\mathbf{13.75}}{\mathbf{0.231 * [DO] + 1.381}} \qquad \textbf{(equation 4)}$$

The growth function described by equation 4 is plotted for exposure durations from 20 to 70 days in **Figure 5** along with a graphic representation of the other components (i.e., CCC, CMC, and FRC) of the proposed DO SSAC for the LSJR. The larval growth function intersects the larval population survival function (i.e., EPA's FRC) at a DO concentration of approximately 4.6 mg/L. This indicates that the larval population survival function would apply at DO concentrations between the CMC of 4.0 mg/L and 4.6 mg/L while the added growth function based on the lobster would apply over the DO range from 4.6 mg/L to the CCC of 5.0 mg/L. Utilizing a combination of the larval population survival function (EPA's FRC) and the larval growth function in this manner, the proposed SSAC for the LSJR provides protection to both larval population recruitment/survival as well as larval growth.

By comparing EPA's DO criteria for the Virginian Province depicted in **Figure 3** with the components of the proposed DO SSAC for the LSJR derived using a slightly modified application of EPA approach as illustrated in **Figure 5**, it is clear that each component of the proposed DO SSAC affords an equal or in most cases a greater level of protection to the aquatic life in the LSJR compared to EPA's criteria for the Virginian Province. Therefore, the proposed SSAC is expected to provide more than adequate level of protection to all aquatic life in the LSJR from exposure to low DO levels.

Derivation of the Proposed SSAC for DO in the LSJR

In accordance with EPA recommendations for the Virginian Province (EPA 2000), the DO range between the CMC of 4.0 mg/L and CCC of 5.0 mg/L would be divided into intervals corresponding to the approximate accuracy of the instrumentation used to make the measurements. For the proposed LSJR SSAC, intervals from 4.0 to 4.2 mg/L; 4.2 to 4.4 mg/L; 4.4 to 4.6 mg/L; 4.6 to 4.8 mg/L; and 4.8 to 5.0 mg/L based on the applicable portions of the larval population recruitment/ survival function (i.e., EPA's FRC) and the larval growth function.

The applicable larval population recruitment/survival function, and the larval growth function shown in **Figure 5** can then be used to derive the acceptable exposure durations for each interval. Using the center point of each interval the maximum allowable cumulative duration of DO levels within the 4.0 to 4.2 mg/L; 4.2 to 4.4 mg/L; and 4.4 to 4.6 mg/L intervals would be 16, 21, and 30 days, respectively, based on the final larval recruitment curve. Likewise, the maximum allowable cumulative duration of DO levels within the 4.6 to 4.8 mg/L and 4.8 to 5.0 mg/L intervals would be 47 and 55 days, respectively, based on the larval growth curve.

Since the biological effect of low DO exposure is cumulative across the DO intervals, the fractional exposures within each range would be summed as proposed by EPA (2000). The

SSAC would be achieved if the sum of the fractional exposures was less than 1. Based on the proposed SSAC for the LSJR, the sum of the fractional exposures between 4.0 and 5.0 mg/L can be expressed as:

$$\left(\begin{array}{c}\textbf{Total Fractional}\\\textbf{Exposure}\end{array}\right)=\frac{\begin{array}{c}\textbf{Days between}\\\textbf{4.0 - < 4.2 mg/L}\end{array}}{\textbf{16 day Max}}+\frac{\begin{array}{c}\textbf{Days between}\\\textbf{4.2 - < 4.4 mg/L}\end{array}}{\textbf{21 day Max}}+\frac{\begin{array}{c}\textbf{Days between}\\\textbf{4.4 - < 4.6 mg/L}\end{array}}{\textbf{30 day Max}}+\frac{\begin{array}{c}\textbf{Days between}\\\textbf{4.6 - < 4.8 mg/L}\end{array}}{\textbf{47 day Max}}+\frac{\begin{array}{c}\textbf{Days between}\\\textbf{4.8 - < 5.0 mg/L}\end{array}}{\textbf{55 day Max}}$$

where the number of days within each interval is based on the daily average DO concentration.

For example, a year with the durations of DO levels for the intervals between 4.0 and 5.0 mg/L as shown in **Table 3**, the Total Fractional Exposure can be expressed as:

$$\textbf{Total Fractional Exposure}=\frac{1}{16}+\frac{4}{21}+\frac{7}{30}+\frac{9}{47}+\frac{12}{55}=0.896$$

Because the sum of the fractional exposures in this case is less than 1 (i.e., 0.896), the proposed SSAC would be achieved assuming the 4.0 mg/L minimum was not exceeded.

DO Interval (mg/L)	Example, Measured Interval Duration (days/year)	Maximum Interval Exposure Duration (days/year) [a]	Fractional Interval Exposure [b]
4.0 - <4.2 mg/L	1	16	0.063
4.2 - <4.4 mg/L	4	21	0.190
4.4 - <4.6 mg/L	7	30	0.233
4.6 - <4.8 mg/L	9	47	0.191
4.8 – <5.0 mg/L	12	55	0.218
Total Fractional Exposure			**0.896**

[a] Maximum exposure durations for intervals between 4.0 and 4.6 mg/L were determined from EPA Final Recruitment Curve and for intervals between 4.6 and 5.0 mg/L maximum exposure durations were determined from the larval growth curve (see Figure 5).

[b] Fractional interval exposure is the measured interval duration divided by the maximum exposure duration for that interval.

Final Proposed SSAC for DO in the LSJR

From the information provided above, the proposed SSAC for DO in the LSJR would be comprised of two parts. The first part of the proposed SSAC is a minimum DO concentration of 4.0 mg/L. In addition, the Total Fractional Exposure to DO levels in the 4.0 to 5.0 mg/L range must also be at or below 1.0 for each annual evaluation period as determined by the equation:

$$\left(\begin{array}{c}\textbf{Total Fractional}\\ \textbf{Exposure}\end{array}\right) = \frac{\begin{array}{c}\textbf{Days between}\\ \textbf{4.0 - < 4.2 mg/L}\end{array}}{\textbf{16 day Max}} + \frac{\begin{array}{c}\textbf{Days between}\\ \textbf{4.2 - < 4.4 mg/L}\end{array}}{\textbf{21 day Max}} + \frac{\begin{array}{c}\textbf{Days between}\\ \textbf{4.4 - < 4.6 mg/L}\end{array}}{\textbf{30 day Max}} + \frac{\begin{array}{c}\textbf{Days between}\\ \textbf{4.6 - < 4.8 mg/L}\end{array}}{\textbf{47 day Max}} + \frac{\begin{array}{c}\textbf{Days between}\\ \textbf{4.8 - < 5.0 mg/L}\end{array}}{\textbf{55 day Max}}$$

where the number of days within each interval is based on the daily average DO concentration.

Therefore, the proposed SSAC for DO in the LSJR would be a minimum concentration of 4.0 mg/L and a Total Fractional Exposure in the range of 4.0 to 5.0 mg/L of 1.0 or less as determined by the equation above. The proposed SSAC would be utilized to assess the ambient DO status of the waters in the LSJR. It is anticipated that permitted discharges would continue to be required to achieve a DO concentration equal to or above the 5.0 mg/L CCC indicated in **Figure 5.**

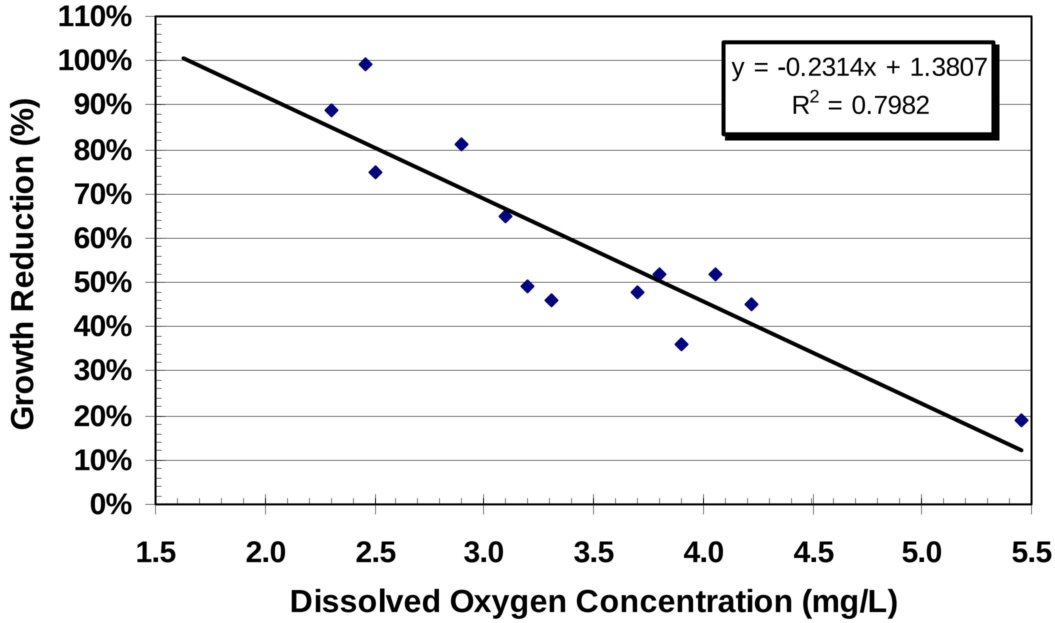


Figure 4. Growth response curve for the American lobster (*Homarus americanus*) exposed to various continuous low DO concentrations. Graph reproduced from EPA 2000.

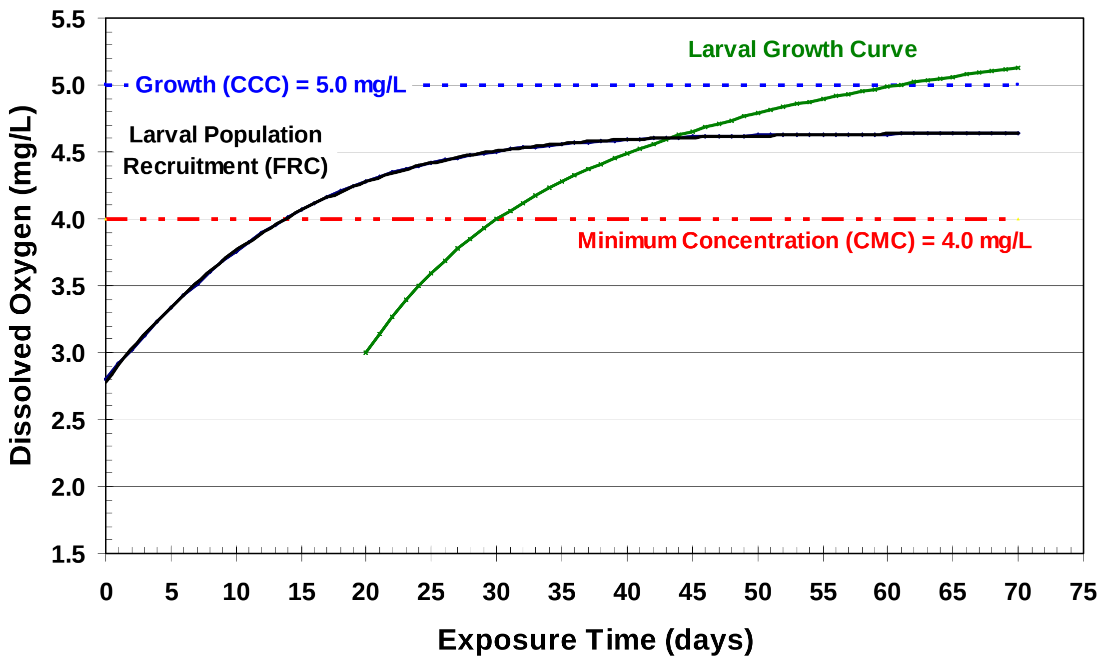


Figure 5. Plot of the various components of the proposed SSAC for DO in the LSJR.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

OCT 10 2006

Ms. Mimi Drew, Director
Water Resource Management
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Dear Ms. Drew:

The U.S. Environmental Protection Agency (EPA) has completed its review of the Site Specific Alternative Criteria (SSAC) for Dissolved Oxygen (DO) in the Lower St. Johns River, Florida Administrative Code 62-302.800(5). This site specific revision to Florida's existing DO criterion was adopted by the Florida Environmental Regulation Commission on May 25, 2006, and submitted to EPA by letter dated June 30, 2005, from Gregory M. Munson, General Counsel of the Florida Department of Environmental Protection, to James I. Palmer, Jr., Regional Administrator. Mr. Munson also certified that the revisions were duly adopted as water quality standards pursuant to state law. The SSAC will become effective for Clean Water Act (CWA) purposes upon approval by EPA.

The revision establishes a SSAC for dissolved oxygen for the Class III marine portion of the lower St. Johns River and its tributaries between Julington Creek and the mouth of the river. Specifically, the SSAC retains the existing minimum concentration of 4 mg/L of dissolved oxygen and replaces the existing 5 mg/L daily average concentration with an annual total fractional exposure (TFE) index of 1.0 that is not to be exceeded. This TFE is established at a level that protects both larval recruitment and growth for aquatic organisms. EPA's *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras* (EPA-822-R-00-012) served as the initial basis for the formulation of this SSAC.

In January 2001, EPA, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service signed a memorandum of agreement (MOA) which governs the exercise of EPA's authorities under Sections 303(c), 304(a), and 402 of the Clean Water Act in relation to EPA's obligations under Section 7 of the Endangered Species Act. This MOA addresses EPA's review and approval of State-adopted water quality criteria for the circumstances of the revisions to Florida's water quality criteria for aquatic life.

EPA's decision to approve the SSAC for DO in the Lower St. Johns River is subject to the results of the national consultation under Section 7 of the Endangered Species Act with the U.S. Fish and Wildlife Service. By approving the SSAC, "subject to the results of the national consultation," EPA retains its discretion to take appropriate

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In summary, this SSAC is consistent with the requirements of the Clean Water Act and 40 CFR Part 131, and I am approving this revision to Florida water quality standards. If you have questions, please contact me at 404-562-9345 or have a member of your staff contact Joel Hansel at 404-562-9274.

Sincerely,

Dee Stewart for

James D. Giattina, Director
Water Management Division

APPENDIX M
DETERMINATION OF NITROGEN AND PHOSPHORUS NON-POINT LOADS FOR URBAN STORMWATER JURISDICTIONS

DETERMINATION OF NITROGEN AND PHOSPHORUS NON-POINT SOURCE LOADS FOR URBAN STORMWATER JURISDICTIONS OF THE LOWER ST. JOHNS RIVER BASIN

John Hendrickson, Environmental Scientist VI,
St. Johns River Water Managmement District
Lower St. Johns River Basin Program

Courtney Hart, GIS Analyst
Idea Integration, Inc.

August 2007

Determination of Nitrogen and Phosphorus Non-Point Source Loads for Urban Stormwater Jurisdictions of the Lower St. Johns River Basin

Purpose

- To allocate urban stormwater load reductions to responsible parties
- To partition urban stormwater into loads emanating from old urban areas developed prior to the requirement of stormwater BMPs, and new urban area loads, a necessary distinction for establishing TMDL formula level 2 and level 3 reductions
- To establish a relative value on which to base trading pollution reductions to other point and non-point entities.
- To determine the spatial characteristics of urban area load reductions for verification of the revised TMDL

Background

This effort represents the third revision of the calculation of urban stormwater/nonpoint source loads for the lower St. Johns River Basin. The first iteration calculated loads only for major governmental entities (whole counties or municipalities with phase I or II NPDES stormwater permits). This calculation was later revised to distinguish MS4 areas within counties. However, this second analysis was incomplete, as it failed to account for urban area loads outside of designated MS4 areas.

This third revision represents the most complete examination of urban stormwater loads from the lower St. Johns River Basin and their categorization with regard to NPDES stormwater permitting authority and the TMDL. Under the TMDL, allowable loadings are allocated between point source loads which are expressed as part of the wasteload allocation(WLA) and nonpoint loads which are part of the load allocations (LA). Although stormwater discharges traditionally are considered to be nonpoint sources of pollution, certain urban stormwater discharges legally are considered to be point sources since they are covered by a NPDES MS4 stormwater permit. These urban stormwater point sources are placed under the WLA side of the TMDL equation. All other loads are placed under the LA category, including natural background loads, atmospheric deposition, augmented nonpoint source loads that occur from agriculture, forestry, and urban development outside of MS4 areas. The finer-scale sub-division of loads under this analysis expands the number or responsible urban stormwater entities contributing to the river's marine reach from eight to sixteen. Together with the freshwater reach loads that are now included in this analysis, there are thirty-seven entities for which urban stormwater loads and TMDL level 2 reductions have been identified.

This urban stormwater load assessment also benefits from more comprehensive GIS land use/land cover data on which to base projected 2008 nutrient loads. In earlier calculations, future loads were estimated from DOT traffic analysis zone population

Table 1. Urban Stormwater Jurisdictions and Areas for the Marine and Freshwater Contributing Basins of the LSJR.

Jurisdiction	WLA	LA	Total Area (Acres)
Marine Reach Contributing Area			
Duval County Marine	X		377,458
Clay Marine UA	X		31,421
St. Johns County Marine UA	X		13,841
Jacksonville Beach	X		4,652
NAS Jacksonville	X		3,843
Mayport NS	X		2,822
Orange Park	X		2,308
Marine Reach WLA Sub-total			**436,345**
Clay Marine Non-UA		X	191,873
Camp Blanding		X	54,929
St. Johns County Marine Non-UA		X	33,334
Penney Farms		X	894
Marine Reach LA Subtotal			**281,029**
Freshwater Reach Contributing Area			
Green Cove Springs	X		3,848
Clay County Fresh UA	X		1,940
Freshwater Reach WLA Sub-total			**5,788**
Putnam County Fresh Non-UA		X	217,472
St Johns County Fresh Non-UA		X	178,548
Clay County Fresh Non-UA		X	54,179
Flagler County Fresh Non-UA		X	4,759
Palatka		X	4,447
Welaka		X	425
Hastings		X	421
Pomona Park		X	219
Freshwater Reach LA Sub-total			**460,470**

[1]UA = Urbanized Area based on 2000 Census data for NPDES Phase II applicability

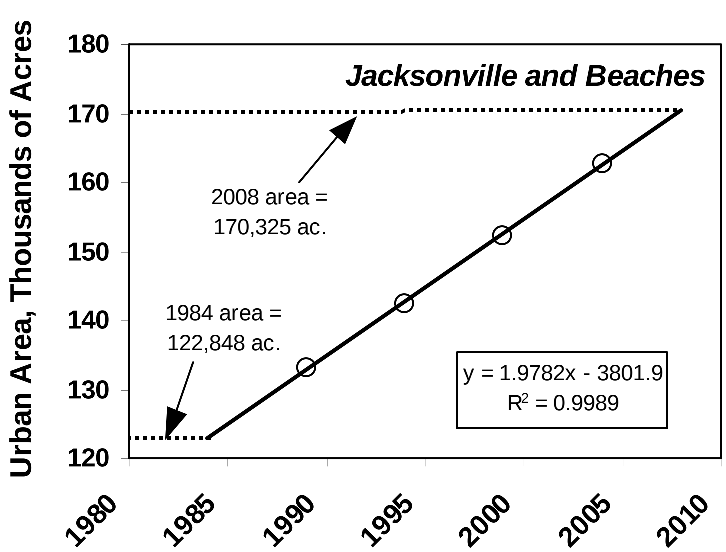
projections, which were then converted by a regression model to urbanized area. Due to the recent availability of 2004 land use/land cover data, this analysis forecasts 2008 urban area through a regression model utilizing four land cover data sets from 1989 through 2004.

Determination of NPDES MS4 Status and 1984 and 2008 Urban Areas

Based on guidance provided by staff at FDEP regarding the determination of responsibilities for urban stormwater under the NPDES program, a GIS coverage was created by combining the boundaries of governmental entities (counties, municipalities, and military installations), established MS4 boundaries, and 2000 census urbanized areas (areas identified with urban stormwater permit requirements under phase II). The resulting coverage relegated the entire area of the LSJR basin into one of 37 mutually-exclusive areas that were NPDES Phase I, NPDES Phase II, or non-NPDES stormwater responsibility. A number of these areas were then re-combined based upon guidance from MS4 permit holders. Most notable among these subsumed areas was the placement of Cecil Field and the Mayport Fuel Depot into the Duval MS4, the combining of the St. Johns County Julington Creek Plantation and Ponte Vedra into one St. Johns UA category, and the placement of the East Palatka area under the Putnam County jurisdiction. The final list contained 21 areas (Table 1; Figure 1). This report does not address the individual entities adding nutrient load to the Crescent Lake Basin, and this contributing watershed is considered to have a single allocation. Also, karst areas within the LSJR basin in eastern Alachua county and western Clay county with no surface water connections to the St. Johns River are excluded from the allocation process.

Successive years of land use/land cover data were overlain on these 37 areas to examine growth trends for the purpose of hindcasting and forecasting the 1984 urban areas (areas presumed to have been developed without stormwater runoff BMPs) and the 2008 urban area (starting point for load allocations). Figure 2 provides an example of how this calculation was performed for the Jacksonville Phase I area. The calculated 1984 and 2008 urbanized areas within each of the jurisdictional entities are listed in Table 2. Urban areas were defined in the land use/land cover data as the sum of low, medium and high density residential, low and high intensity commercial, and industrial classes.

Figure 2. Example of urban area load extrapolation to 1984 and 2008 for the Jacksonville and Beaches MS4 area.



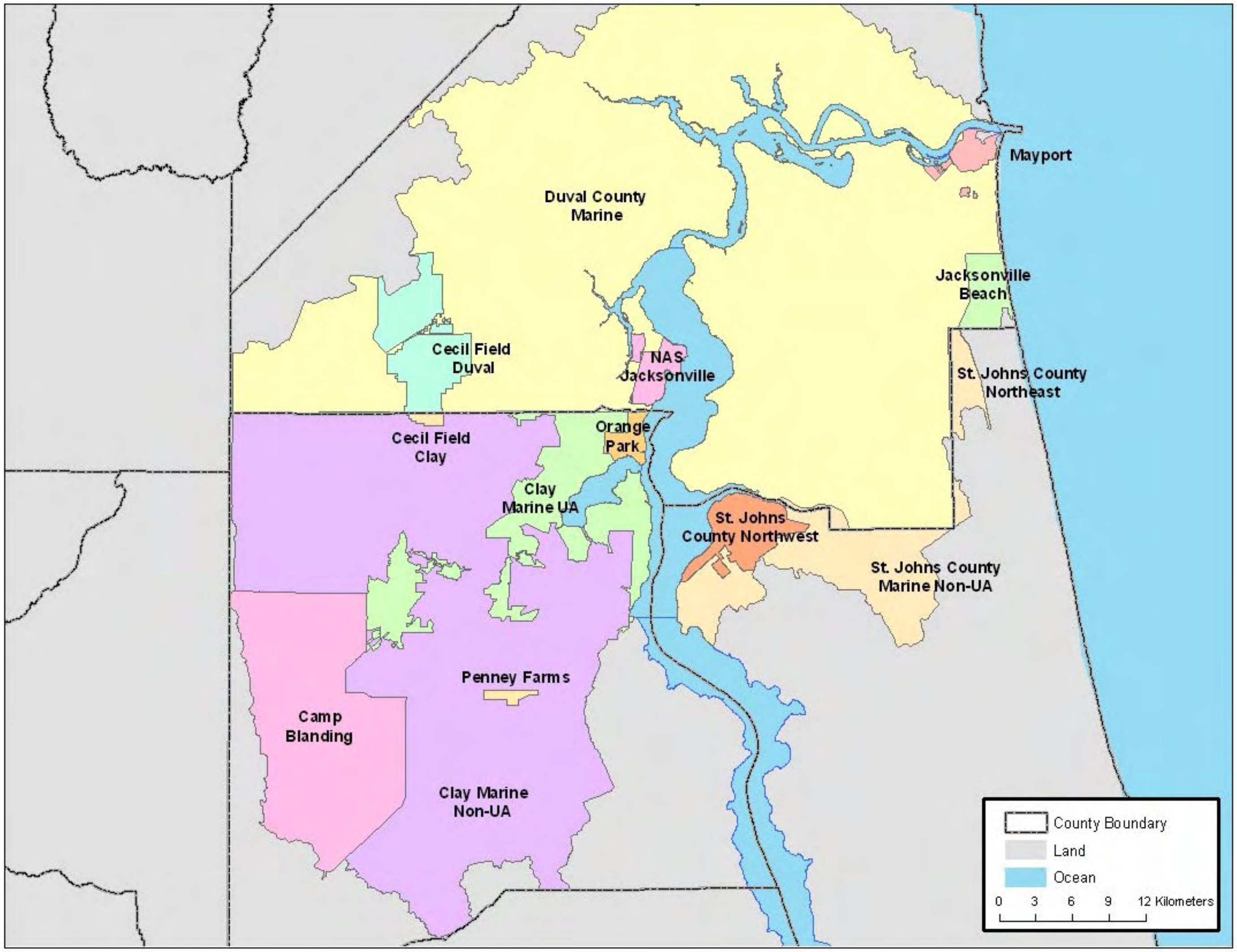


Figure 1. Urban Stormwater Jurisdictions Controbuting to the Marine Reach of the Lower St. Johns River.

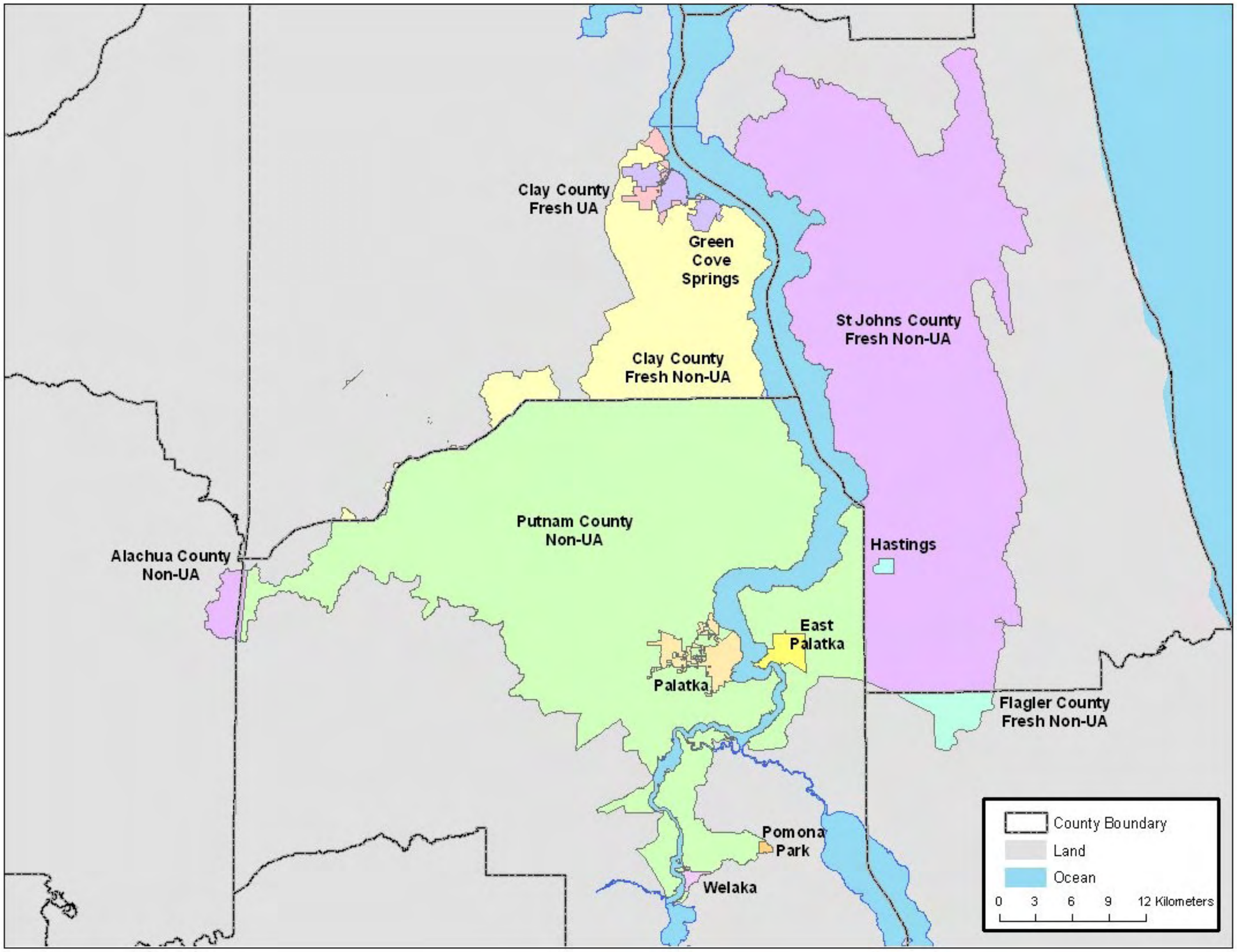


Figure 1. Urban Stormwater Jurisdictions Contributing to the Freshwater Reach of the Lower St. Johns River.

Table 2. Estimated 1984 and 2008 Urbanized Areas within Urban Stormwater Entities

Jurisdiction	WLA	LA	Urban Areas, acres[1]						Comments[2,3]
Marine Reach			**1984**	1989	1994	1999	2004	**2008**	
Duval County Marine	X		**125,895**	136099	144622	154536	165417	**173,023**	8.0088*(x/100) - 1539; R2=0.99
Clay Marine UA	X		**15,001**	16375	19371	21253	22138	**24,203**	155.22x - 301883; R2=0.94
St. Johns County Marine UA	X		**4,219**	5338	5827	7084	8617	**9,445**	[4] 22.281x - 43282; R2=0.99 (SJ East); 77.347x - 152947; R2=0.97 (SJ West)
Jacksonville Beach	X		**2,107**	2265	2390	2610	2703	**2,844**	12.443x - 23834; R2=0.98
NAS Jacksonville	X		**2,475**	2476	2311	2367	2482	**2,482**	No clear trend
Mayport NS	X		**1,434**	1434	1313	1305	1387	**1,387**	No clear trend
Orange Park	X		**1,936**	1937	1954	2011	2004	**2,004**	No clear trend
Clay Marine Non-UA		X	**16,860**	16860	16780	17823	20232	**21,395**	139.73x - 271916; R2=0.95
Camp Blanding		X	**3,022**	3022	2404	2407	2674	**2,674**	No clear trend
St. Johns Co. Marine Non-UA		X	**1,112**	1470	1981	2051	2697	**2,912**	30.375x - 59814; R2=0.93
Penney Farms		X	**185**	202	195	228	228	**228**	No clear trend
Freshwater Reach									
Green Cove Springs	X		**2,188**	2188	2247	1965	2041	**2,041**	No clear trend
Clay County Fresh UA	X		**1,152**	1152	1102	1121	1098	**1,098**	No clear trend
Putnam County Fresh Non-UA		X	**20,764**	20213	23466	24319	25925	**27,603**	146.28x - 282829; R2=0.94
St Johns County Fresh Non-UA		X	**4,700**	8380	8832	14670	16237	**18,817**	238.13x - 470547; R2=0.90
Clay County Fresh Non-UA		X	**2,466**	2466	3540	3446	3476	**3,476**	No clear trend
Flagler County Fresh Non-UA		X	**3**	3	2	3	6	**6**	No clear trend
Palatka		X	**3,169**	3169	3044	3009	3050	**3,050**	No clear trend
Welaka		X	**384**	327	311	306	197	**195**	-3.1981x + 6500.6, R2=0.73
Hastings		X	**229**	229	245	239	234	**234**	No clear trend
Pomona Park		X	**65**	65	79	79	29	**29**	No clear trend

1Urban areas 1989 - 2004 from GIS Land Use coverages; 1984 and 2008 predicted.
2Regression equations based on areas in hectares; x=year
3If no clear growth trend, 1989 Urban Area =1984; 2004 Urban area = 2008
4Growth flat until 95-99; linear regression under-predicts 1984 and 2008. Trend determined from 1995-2004

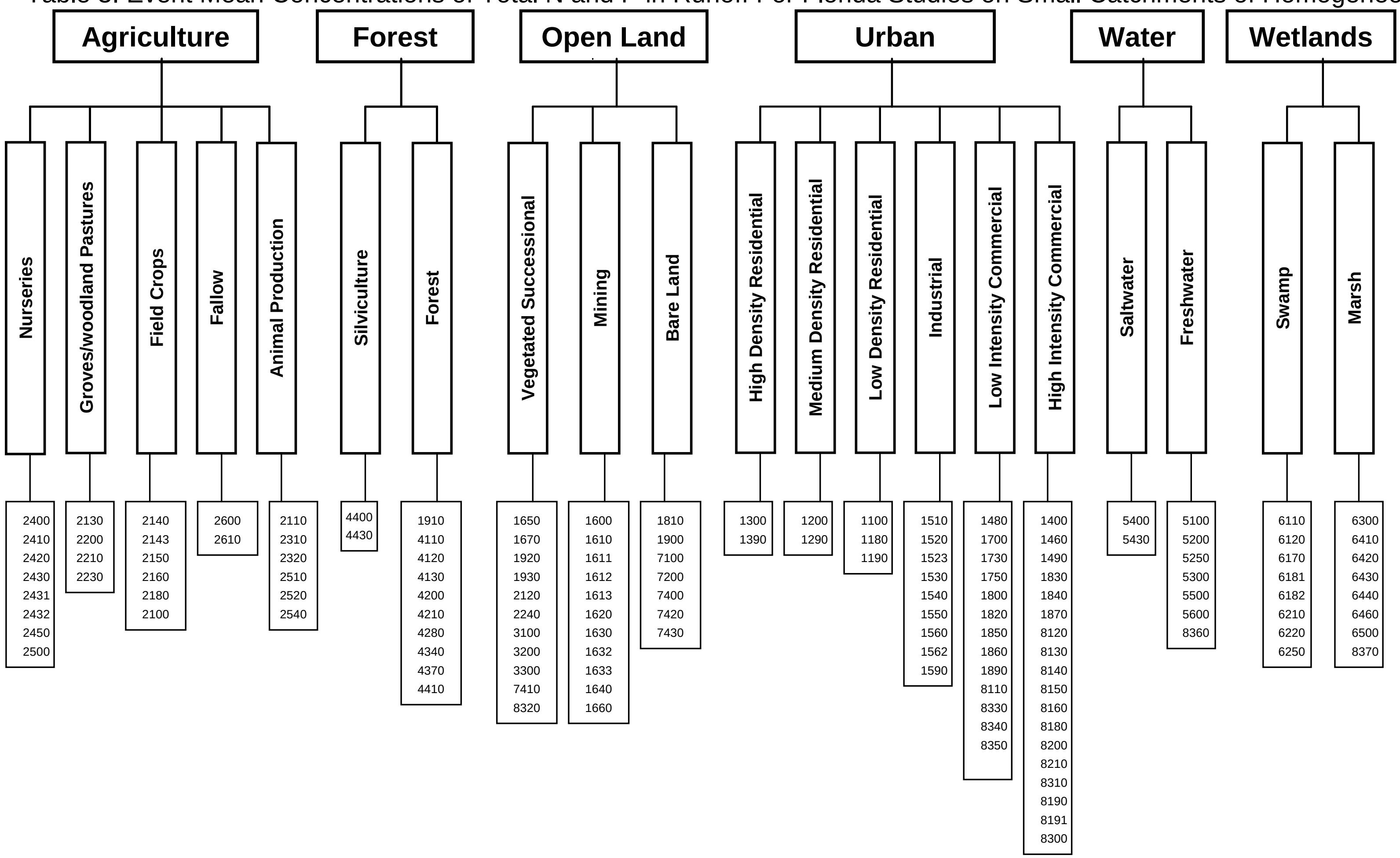
Estimation of Representative Nutrient Concentrations for Urban Areas

The underlying concepts embodied in the non-point source watershed modeling for the TMDL were employed to estimate urban area stormwater loads,. In this model, nutrient load in runoff for an area is calculated as the product of separately determined estimates of concentration and runoff volume. The model relies upon the premise that nutrient concentrations and runoff volume tend to be similar for characteristic land development types, owing to the fact that these land development types and the ensuing activities within them have similar nutrient-generating aspects. These land development types are derived from the Florida Land Use Land Cover classification system, with the lowest level urban delineations in this data layer aggregated into six super-groups of land use (low density residential, medium density residential, high density residential, low intensity commercial, high intensity commercial, and industrial), represented by the level II land uses of Figure 3. Because there are significant climactic, physiographic and developmental (mostly infrastructure related) regional aspects to the propensity for nutrient export in runoff from urban lands, regional data should be used to characterize typical land use-water quality. Harper (1994) has compiled data for studies conducted in Florida, to produce regionally relevant water quality statistics for these land uses.

The land use water quality values used for the LSJR TMDL are fundamentally different than the Harper (1994) in their derivation. While the Harper data are compiled from nitrogen and phosphorus concentrations measured in runoff from small catchments of one predominant land development type (typically tens of acres in size), the LSJR TMDL watershed model values were derived from water quality monitoring data from 30 well-sampled tributaries draining large watersheds (tens to hundreds of square miles) in the LSJR basin. Specific land use water quality concentrations were calculated with multiple regressions relating seasonal flow-weighted concentrations to the fractions of major (level I; Figure 3) watershed land use. In watersheds where only urban development was present, TN and TP coefficients were also determined by extrapolating the fraction of developed area – nutrient concentration regressions to the point of 100 percent watershed land cover, as shown in the example of Figure 5. The resulting LSJR concentrations are lower that the Harper (1994) values (Table 3; Figure 4), presumably because sedimentation, denitrification and assimilation by primary and secondary producers reduces nutrients from their point of mobilization. The LSJR watershed model coefficients were adjusted in this manner to provide the most accurate values of watershed load to the river water quality model, as actual measured data is generally preferred over unsubstantiated literature values when such accuracy is desired (Donigian and Huber, 1991). For urban land use as a whole, the LSJR nitrogen concentrations tend to be 67 percent of the Harper literature data, while phosphorus values are similar (95 percent). The runoff coefficient (RC) values, the fraction of incident rainfall that ultimately ends up in streamflow at a broad temporal scale, tend to be half of the Harper literature values. The departure in RC arises from the very low value for low density residential in the LSJR TMDL model, which was assigned to reflect very low

Figure 3. Hierarchy of Land Use Classifications Used in the LSJR TMDL Non-point Source Nutrient Load Modeling. Top level alnd use categories are referred to as "Level I"; Mid-level categories are referred to as "Level II". Bottom boxes of the tree identify the Florida Land Use Land Classification Codes aggregated into the Level II categories.

Table 3. Event Mean Concentrations of Total N and P in Runoff For Florida Studies on Small Catchments of Homogeneous



Land Use, and Values derived by Regression From Large Watershed Monitoring Data of the LSJR Basin. (*)RC values reflect rural homestead-level development, and were not used in determining the RCs for new development.

	Source	Variable	Low Density Residential	Med. Density Residential	High Density Residential	Low Intensity Commercial	High Inten. Commercial	Industrial
Typical Florida Values, Small Catchment of Homogeneous Land Use	Harper, 1994	N	1.77	2.29	2.42	1.18	2.83	1.79
		P	0.177	0.300	0.490	0.150	0.430	0.310
		RC Avg. Yr	0.268	0.373	0.675	0.837	0.887	0.793
LSJR TMDL Values, Based on Whole Watershed Land Use	Hendrickson and Konwinski, 1998	N	0.80	1.50	1.83	1.20	1.83	1.23
		P	0.080	0.300	0.443	0.240	0.443	0.257
		RC Avg. Yr.	0.123*	0.381	0.406	0.381	0.417	0.381
		RC Dry Yr.	0.090*	0.278	0.296	0.278	0.305	0.278

Figure 4. Comparison of LSJR TMDL and Small Catchment, Homogeneous Land Use N and P Concentrations in Runoff.

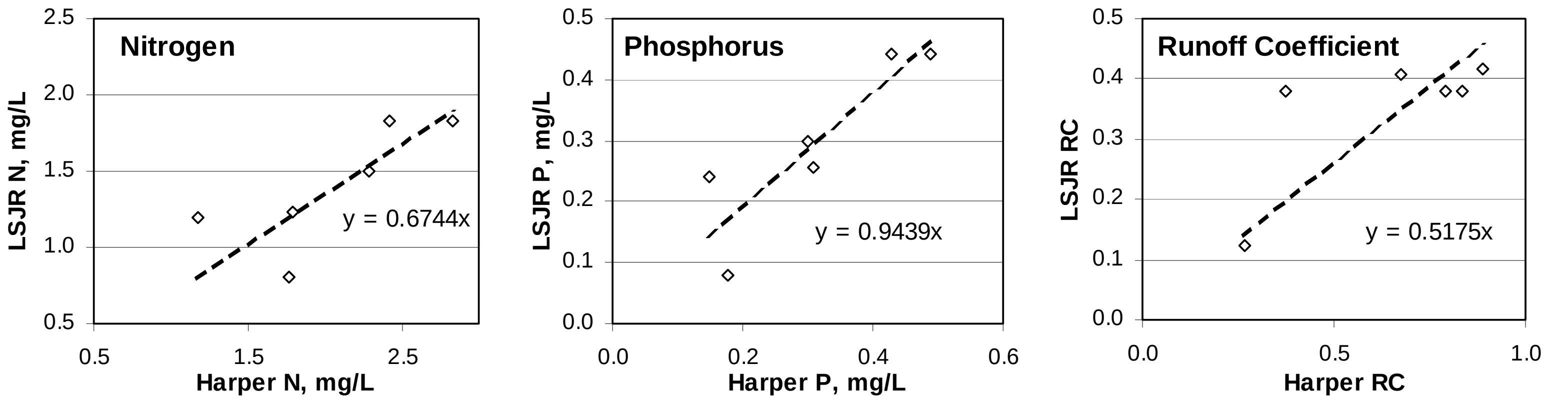
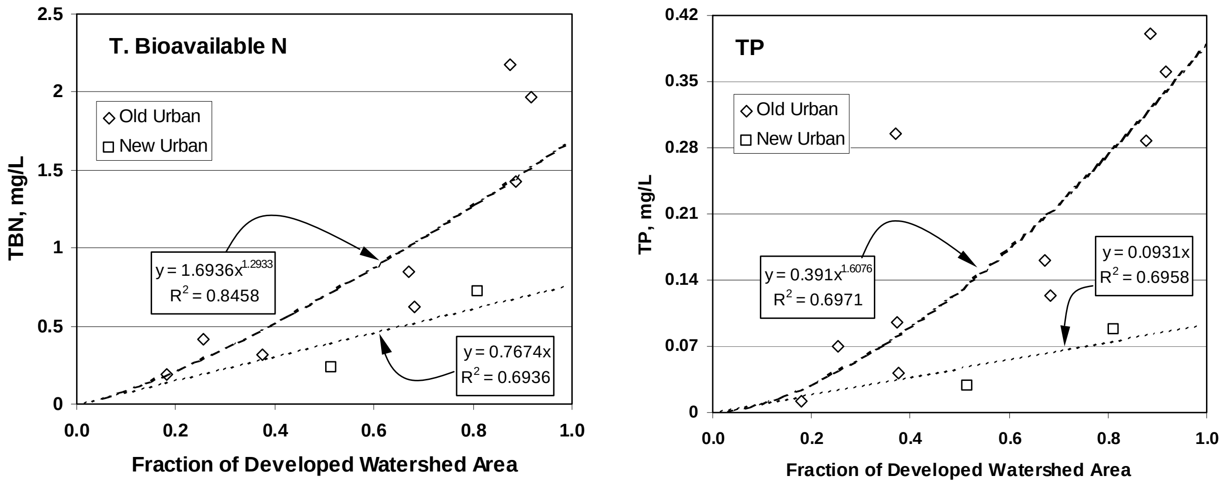


Figure 5. Comparison of Old Urban and New Urban (Post 1984 with Environmental Resource Permit Development Practices) Nitrogen and Phosphorus Concentrations in Runoff.



development density typical of rural homesteads, and does not reflect the development density assigned to low density residential in the LSJR basin. Due to this large departure from the Harper literature values, this RC value was not used in load calculations for new development.

The LSJR TMDL typical urban area nutrient concentrations are considered to be representative of “old” urban because the data from which they are derived were collected in the early to mid 1990’s from streams draining areas developed prior to 1984, located in the densely developed areas of Jacksonville and northern Clay County. There are several noteworthy characteristics of development subsequent to 1984 that reduce the nutrient concentrations in runoff. The addition of stormwater treatment requirements, impervious area runoff retention, wetland protection, lower overall development density, and the use of sanitary sewer collection instead of septic tanks all are believed to play a role in the lower N and P concentrations observed in post-1984 development. While it would have been possible to model, in a more mechanistic way, typical N and P concentrations representative of newer development by applying literature values on the typical efficiency of stormwater treatment practices, it was felt that this would under-represent the total nutrient load reduction that occurs from the “treatment train” of the additional characteristics listed above. This approach would also not be able to characterize the nature of changes that current stormwater treatment has on the lability of organic nitrogen, a necessary piece of information in subsequent river water quality modeling (a significant portion of organic nitrogen in natural blackwater stream runoff is refractory, or not readily assimilable by algae in time relevant time frames). For these reasons, monitoring from watersheds of only new development was again relied upon to extrapolate to 100 percent model coefficients. Presently, there is a limited amount of data from watersheds dominated by new development, but several sub-watersheds within the large developments of regional impact of Eagle Harbor and Julington Creek Plantation have sufficient data to make preliminary estimates. Using the procedure of extrapolating the developed area of these newly developed residential and commercial developments to 100 percent (Figure 5), a “new” development total bioavailable N (TBN) concentration of around 0.93 mg/L, and TP concentration of around 0.13 mg/L, can be calculated.

Due to the increased amount of impervious surface area in urbanized watersheds, a greater amount of rainfall is directed to runoff, thus increasing the nutrient load. The mean of urban land use RC values used in the TMDL modeling (again representative of older urban areas at a watershed scale) ranged from 0.123 to 0.417, with an average of 0.393 (low density residential omitted). This RC value represents the ratio of runoff to rainfall volume for the watershed scale, long-term average rainfall condition, but in a dry year, the propensity for a rainfall event to generate runoff is reduced, due to soil and vegetation moisture deficits. To account for this in the stormwater source load estimate, the RC was varied based upon a calibration to the ratio of the particular season's rainfall to the long-term rain for that season and for previous seasons, with a factor referred to as the long-term rain ratio. Thus, for the extreme 1999 dry-year case, the urban RC ranged from 0.09 to 0.305, with and overall mean value of 0.287 (low density residential omitted). Insufficient information exists to characterize an RC representative of new urban development at the watershed scale, so this value was estimated by multiplying a hydrologic efficiency of 0.8 for stormwater wet ponds (hydrologic efficiency being the ratio of wet pond exiting volume to that of the total incoming volume; this value is assumed less than 1, as wet pond water volume is lost to evapotranspiration and shallow ground water infiltration) times the aggregate urban land runoff coefficients for average or dry years.

N and P removal Efficiencies for Calculation of TMDL Level 2 Reductions

Nutrient pollutant removal achieved by retrofitted best management practices is dependent upon the particular nutrient form, the treatment system, and the design considerations of the particular system. Even for specific system types, removal efficiencies are highly variable.

Because wet detention if the most commonly applied system for urban stormwater retrofit, published efficiencies for this type of system were used. CDM (2002) provides a range for treatment efficiency for TP of 40 to 50 percent, for TKN of between 20 to 30 percent, and for NO_X of between 30 to 40 percent. Harper (2003) provides equations on the efficiency of wet detention systems based upon residence time. For a 2-week retention time (typical wet pond design target), removal efficiencies were calculated as:

Total N: 8.4126*[Ln(Time, Days)] + 27.25 = 49%
Total P: 8.0847*[Ln(Time, days)] + 44.583 = 66%

Winer (2000) lists nutrient pollution removal efficiencies for stormwater wet ponds of 51% for TP, 66% for soluble P, 33% for TN and 43% for NOX. For calculation of removal efficiencies commensurate with level 2 stormwater retrofit, conservative, low to mid range values have been selected of 30% for TN, and 50% for TP.

Estimation of Urban Area Loads

The Florida Watershed Restoration Act of 1999 directed the Department of Environmental Protection to convene a committee of experts to advise the legislature on the approach to allocating sustainable pollutant loads under the TMDL process. This Allocation Technical Advisory Committee (FDEP, 2001) recommended a stepped process for the reduction of pollutant loads to water bodies. A central concept to this allocation process was that while point sources of pollution throughout the State had instituted accepted technologies to reduce pollutant load, and were operating under permit, most non-point sources of pollution continued unabated. It was the consensus of the committee that reductions in pollutant load should begin first with uncontrolled (non-treated) urban stormwater runoff, prior to the requirement of higher treatment levels from point sources of pollution. Urban stormwater sources were to first institute stormwater management for 45 percent of uncontrolled areas (referred to as level 1), and if this was insufficient, expand area of treatment to 90 percent of uncontrolled areas (level 2). If the level 2 urban stormwater control was insufficient to achieve the TMDL, then point and nonpoint sources shared equal burdens to reduce the remaining excess load.

To apply this allocation guidance to urban stormwater sources of nutrient pollution in the LSJR basin, N and P loads were estimated for:

1. urban areas without stormwater treatment, presumed to be all urban development that occurred prior to the enactment of F.A.C. 40C-4 (Management and Storage of Surface Waters), and later, the general Environmental Resource Permit (F.A.C. 40C-42), as this load would need to be assessed level 1 or level 2 reductions; and
2. urban development with stormwater BMPs, presumed to be new development, or that development that has occurred since 1984, forecast to 2008.

To calculate the untreated urban area loads, the 1989 land use data was aggregated into the six urban subclasses for which typical water quality nutrient concentrations have been determined (Table 2), and loads determined as:

$$(NC_i)*(RC_i)*(RAIN_j)*(AREA_k)$$

Where:

NC_i = the nutrient concentration for land use *i*
RC_i = the runoff coefficient for land use *i*
$RAIN_j$ = the rainfall amount for the year *j*, the average annual condition for the freshwater reach, or the dry year total for the marine reach, and
$AREA_k$ = the area of urban land use *i* for MS4 area *k*.

The urban N and P loads derived from the 1989 land use data were multiplied by the ratio of the 1984 urban area:1989 urban area ratio, with the 1984 urban area predicted by the urban area change over time regressions of Table 2, to provide an estimate of 1984 urban area load.

To estimate the N and P load associated with urban development subsequent to 1984, the formula above was again applied, with the overall urban concentration values of 0.93 mg/L N and 0.13 mg/L P used to represent the aggregate of all urban development categories. Runoff volume was estimated with mean RC values of 0.387 for the average year rain condition, or 0.293 to reflect the dry year condition, with each of these values multiplied by 0.8 to reflect the reduction in runoff by stormwater pond hydraulic efficiency. These single values were used in this load calculation, rather than individual land use category coefficients, as data are not currently available to calculate these watershed scale “new development” rates.

Tables 4 through 7 list the calculated old urban development loads, new urban development loads, total loads and level 2 reductions for both the marine reach and freshwater reach contributing watersheds of the LSJR basin. Old urban area loads are calculated as described above and summed for each of the individual loads of the six urban land development categories, while new urban area loads are determined from the single composite nitrogen and phosphorus concentration and RC values described above. Level 2 load reductions are determined on the old urban area load only, using the 30 percent reduction for nitrogen and 50 percent reduction for phosphorus described above.

Other Considerations

- It should be noted that these calculations concentrate only on the estimation of nitrogen and phosphorus stormwater loads for urban areas, on the distinction of old urban areas that would indicate candidate loads for level 2 reductions, and the changes in this load representative of average rainfall years and the 1999 dry year. Additional TMDL level 3 load reductions are levied upon these urban stormwater jurisdictions through a separate calculation that incorporates point source loads.
- The old urban area loads calculated here should theoretically be greater than the actual loads, as most of these jurisdictions have instituted some levels stormwater retrofit in their older urban areas, extension of sanitary sewer service, street sweeping, etc., that would act to reduce the loads. Credit can be claimed for nutrient load reduction from such projects and activities.
- While stormwater entities have been delineated for the Crescent Lake Basin, the calculations have not been presented on their old and new development loads and reductions, as at this point in the TMDL allocation process the basin is being provided with a single allocation.

Table 4. Calculated **Average Rainfall** Urban Stormwater Source Nitrogen Loads for Jurisdictions of the Marine Reach of the Lower St. Johns River, MT/yr.

Marine Reach Jurisdiction	**WLA**	**LA**	**1984/1989 Urban Area Ratio**	**Old (1984) Urban Area TN Load, (MT/yr)**	**New Urban Area TN Load, 1984-2008, (MT/yr)**	**Total 2008 Projected TN Load, (MT/yr)**	**Level 2 Reduction (90% Old Urban Retrofit, MT/yr)**
Jacksonville, FDOT and Beaches	X		0.93	346.5	74.9	421.5	93.6
Clay Co. Marine w/in UA	X		0.89	28.2	14.4	42.7	7.6
St. Johns Co.	X		0.80	10.4	8.2	18.7	2.8
Jacksonville Beach	X		0.94	7.3	1.1	8.4	2.0
NAS Jacksonville	X		1.00	8.0	0.0	8.1	2.2
Orange Park	X		1.00	5.7	0.1	5.8	1.6
Mayport NS	X		1.00	4.7	0.0	4.7	1.26
Clay Co. Marine non-UA		X	0.95	15.3	7.2	22.5	4.14
Camp Blanding		X	1.00	4.4	3.4	7.9	1.2
SJC remaining marine		X	0.80	1.8	2.2	4.0	0.5
Penney Farms		X	0.94	0.2	0.1	0.3	0.1

TOTAL				**432.5**	**111.6**	**544.6**	**117**

Table 5. Calculated **Dry-Year (1999)** Urban Stormwater Source Nitrogen Loads for Jurisdictions of the Marine Reach of the Lower St. Johns River, MT/yr.

Marine Reach Jurisdiction	WLA	LA	1984/1989 Urban Area Ratio	Old (1984) Urban Area TN Load, (MT/yr)	New Urban Area TN Load, 1984-2008, (MT/yr)	Total 2008 Projected TN Load, (MT/yr)	Level 2 Reduction (90% Old Urban Retrofit, MT/yr)
Jacksonville, FDOT and Beaches	X		0.93	206.3	44.4	247.4	55.7
Clay Co. Marine w/in UA	X		0.89	16.7	8.5	25.2	4.5
St. Johns Co.	X		0.80	5.9	4.9	10.5	1.6
Jacksonville Beach	X		0.94	4.3	0.7	5.0	1.2
NAS Jacksonville	X		1.00	4.8	0.0	4.8	1.3
Orange Park	X		1.00	3.4	0.1	3.5	0.9
Mayport NS	X		1.00	2.8	0.0	2.8	0.7
Clay Co. Marine non-UA		X	0.95	8.4	4.2	12.1	2.3
Camp Blanding		X	1.00	2.6	2.0	4.7	0.7
SJC remaining marine		X	0.80	1.1	1.3	2.4	0.3
Penney Farms		X	0.94	0.1	0.0	0.2	0.0
TOTAL			**256.4**	**66.1**	**318.6**	**69.2**	**256.4**

Table 6. Calculated **Average Rainfall** Urban Stormwater Source Nitrogen Loads for Jurisdictions of the Freshwater Reach of the Lower St. Johns River, MT/yr.

NITROGEN Freshwater Reach Jurisdiction	WLA	LA	1984/1989 Urban Area Ratio	Old (1984) Urban Area TN Load, (MT/yr)	New Urban Area TN Load, 1984-2008, (MT/yr)	Total 2008 Projected TN Load, (MT/yr)	Level 2 Reduction (90% Old Urban Retrofit, MT/yr)
Green Cove Springs	X		1.00	6.96	0.00	6.96	1.88
Clay Co. Fresh w/in UA	X		1.00	2.77	0.00	2.77	0.75
Putnam Co. non-UA		X	1.03	32.78	10.84	43.62	8.85
St. Johns Co. non-UA		X	0.56	4.96	22.25	27.21	1.34
Palatka		X	1.00	9.68	0.00	9.68	2.61
Clay Co. Fresh non-UA		X	1.00	3.99	1.60	5.59	1.08
Welaka		X	1.17	1.17	0.00	1.17	0.32
Hastings		X	1.00	0.62	0.01	0.62	0.17
Alachua Co. non-UA		X	1.00	0.10	0.54	0.64	0.03
Pomona Park		X	1.00	0.11	0.00	0.11	0.03
Flagler Co. Non-UA		X	1.00	0.00	0.01	0.01	0.00

Table 7. Calculated **Average Rainfall** Urban Stormwater Source Phosphorus Loads for Jurisdictions of the Freshwater Reach of the Lower St. Johns River, MT/yr.

PHOSPHORUS Freshwater Reach Jurisdiction	WLA	LA	1984/1989 Urban Area Ratio	Old (1984) Urban Area TP Load, (MT/yr)	New Urban Area TP Load, 1984-2008, (MT/yr)	Total 2008 Projected TP Load, (MT/yr)	Level 2 Reduction (90% Old Urban Retrofit, MT/yr)
Green Cove Springs	X		1.00	1.10	0.00	1.10	0.49
Clay Co. Fresh w/in UA	X		1.00	0.40	0.00	0.40	0.18
Putnam Co. non-UA		X	1.03	4.47	1.52	6.00	2.01
St. Johns Co. non-UA		X	0.56	1.51	0.00	1.51	0.68
Palatka		X	1.00	0.62	3.11	3.73	0.28
Clay Co. Fresh non-UA		X	1.00	0.54	0.22	0.77	0.24
Welaka		X	1.17	0.17	0.00	0.17	0.08
Hastings		X	1.00	0.09	0.00	0.09	0.04
Alachua Co. non-UA		X	1.00	0.02	0.00	0.02	0.01
Pomona Park		X	1.00	0.01	0.08	0.08	0.00
Flagler Co. Non-UA		X	1.00	0.00	0.00	0.00	0.00

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APPENDIX N

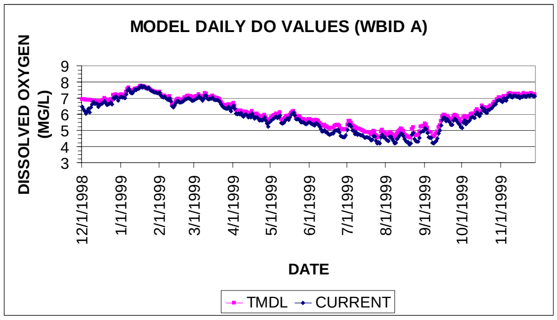
COMPARISONS BETWEEN EXISTING 1999 SIMULATION AND TMDL SIMULATION FOR MARINE WBID DO AND FRESHWATER CHLOROPHYLL

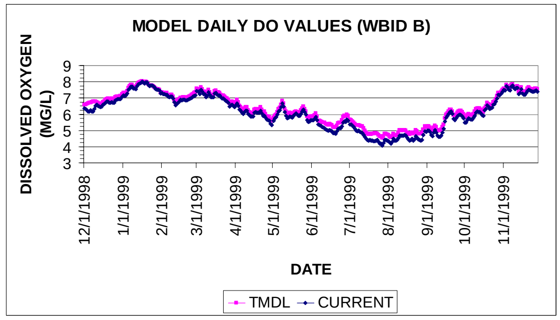
Daily average DO and total fractional exposure under the current conditions simulation for 1999 in WBIDs 2213A – 2213D

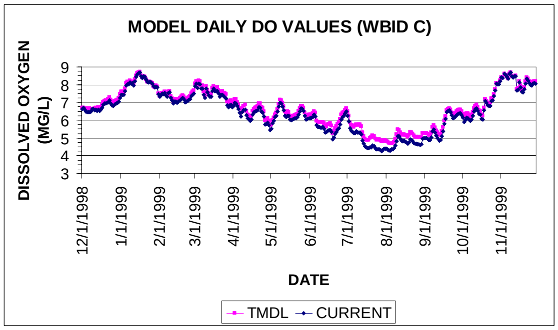
	WBID Minimum Daily Mean DO				WBID Mean SSAC Dose			
YEAR	A	B	C	D	A	B	C	D
1999	4.13	4.06	4.26	4.39	2.62	2.00	1.59	0.56

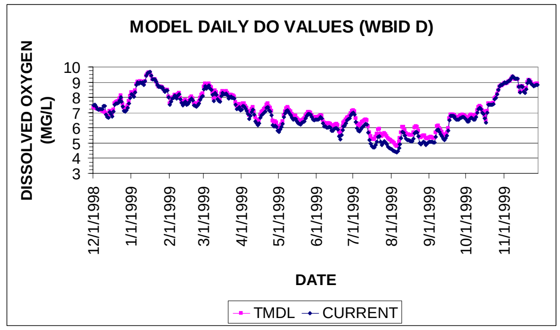
Daily average DO and total fractional exposure under the TMDL simulation for 1999 in WBIDS 2213A – 2213D

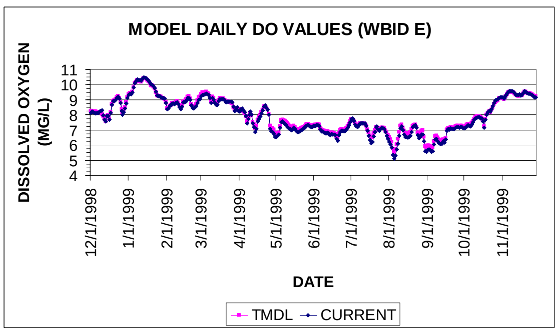
	WBID Minimum Daily Mean DO				WBID Mean SSAC Dose			
YEAR	A	B	C	D	A	B	C	D
1999	4.52	4.53	4.66	4.8	0.99	0.87	0.42	0.06

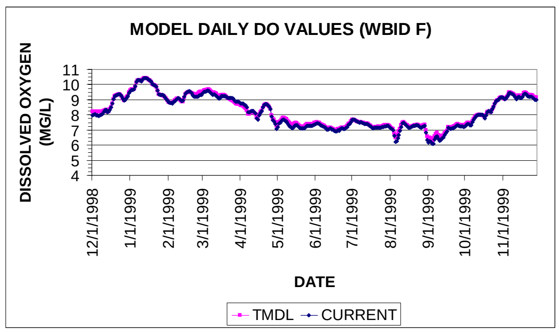

MODEL DAILY DO VALUES (WBID A)
DISSOLVED OXYGEN (MG/L)
9
8
7
6
5
4
3
12/1/1998
1/1/1999
2/1/1999
3/1/1999
4/1/1999
5/1/1999
6/1/1999
7/1/1999
8/1/1999
9/1/1999
10/1/1999
11/1/1999
DATE
TMDL
CURRENT


MODEL DAILY DO VALUES (WBID B)
DISSOLVED OXYGEN (MG/L)
9
8
7
6
5
4
3
12/1/1998
1/1/1999
2/1/1999
3/1/1999
4/1/1999
5/1/1999
6/1/1999
7/1/1999
8/1/1999
9/1/1999
10/1/1999
11/1/1999
DATE
TMDL
CURRENT


MODEL DAILY DO VALUES (WBID C)
DISSOLVED OXYGEN (MG/L)
9
8
7
6
5
4
3
12/1/1998
1/1/1999
2/1/1999
3/1/1999
4/1/1999
5/1/1999
6/1/1999
7/1/1999
8/1/1999
9/1/1999
10/1/1999
11/1/1999
DATE
TMDL
CURRENT


MODEL DAILY DO VALUES (WBID D)
DISSOLVED OXYGEN (MG/L)
10
9
8
7
6
5
4
3
12/1/1998
1/1/1999
2/1/1999
3/1/1999
4/1/1999
5/1/1999
6/1/1999
7/1/1999
8/1/1999
9/1/1999
10/1/1999
11/1/1999
DATE
TMDL
CURRENT

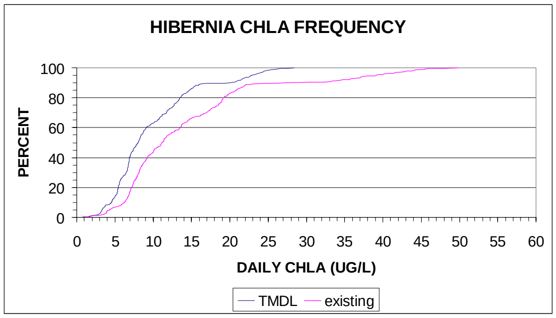

MODEL DAILY DO VALUES (WBID E)
DISSOLVED OXYGEN (MG/L)
11
10
9
8
7
6
5
4
12/1/1998
1/1/1999
2/1/1999
3/1/1999
4/1/1999
5/1/1999
6/1/1999
7/1/1999
8/1/1999
9/1/1999
10/1/1999
11/1/1999
DATE
TMDL
CURRENT

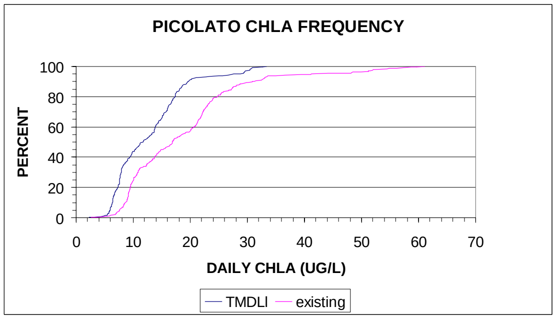

MODEL DAILY DO VALUES (WBID F)
DISSOLVED OXYGEN (MG/L)
11
10
9
8
7
6
5
4
12/1/1998
1/1/1999
2/1/1999
3/1/1999
4/1/1999
5/1/1999
6/1/1999
7/1/1999
8/1/1999
9/1/1999
10/1/1999
11/1/1999
DATE
TMDL
CURRENT

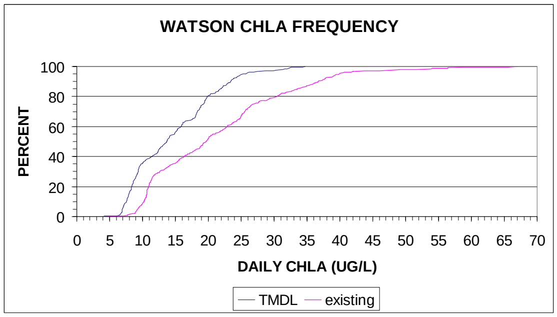
KEY STATISTICS FOR SELECTED FRESHWATER SITES FROM 1999 MODEL YEA SIMULATIONS

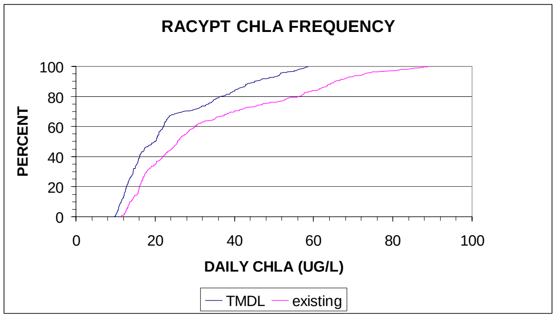
Statistic	Hibernia		Picolata		Racy Pt.		Federal Pt.		
	Existing	TMDL	Existing	TMDL	Existing	TMDL	Existing	TMDL	Ex
Chla min (ug/L)	0.92	0.84	2.64	2.3	11.4	9.74	11.06	10.6	
Chla max (ug/L)	49.82	28.46	61.06	33.4	89.24	58.6	88.84	61.42	
Chla median (ug/L)	11.16	8.01	16.88	11.73	25.68	20.05	28.14	21.92	
# days Chla > 40 ug/L	16	0	20	0	109	55	122	77	
% of year Chla > 40 ug/L	4.4	0	5.5	0	29.9	15.1	33.4	21.1	
# Consecutive days Chla > 40 ug/L	10	0	13	0	39	21	53	43	

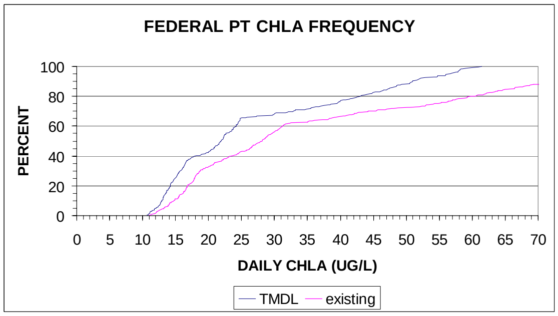
CUMULATIVE FREQUENCY DAILY CHLA PLOTS FOR 1999 BASED ON MODEL SIMULATION OF THE EXISTING AND TMDL SCENARIOS

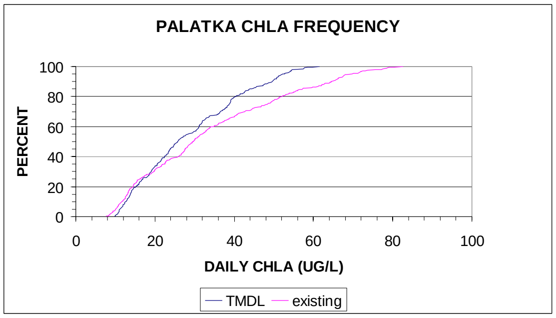






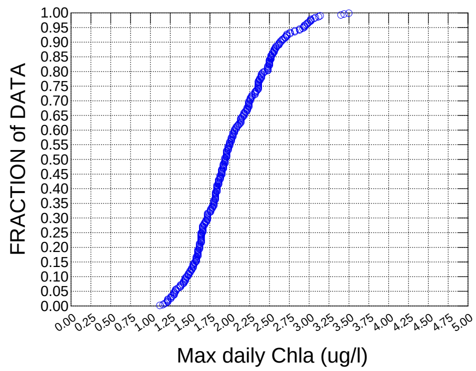




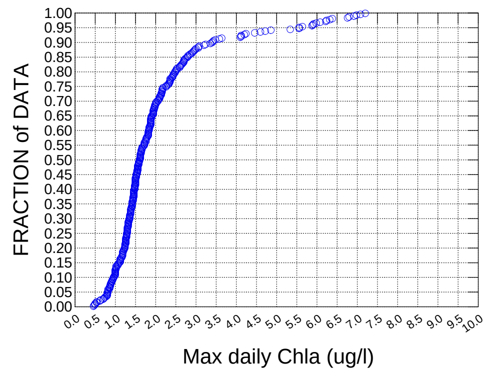


CUMULATIVE FREQUENCY PLOTS FOR DAILY CHLA MAXIMUM FROM THE 1999 TMDL SIMULATION

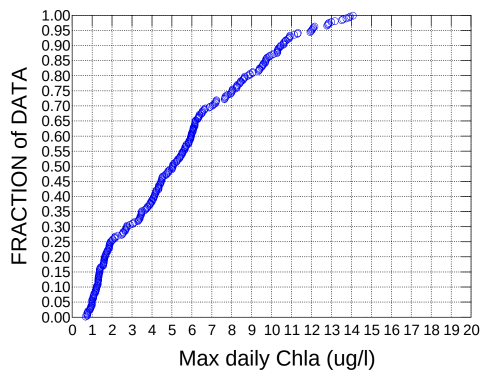
FULTON



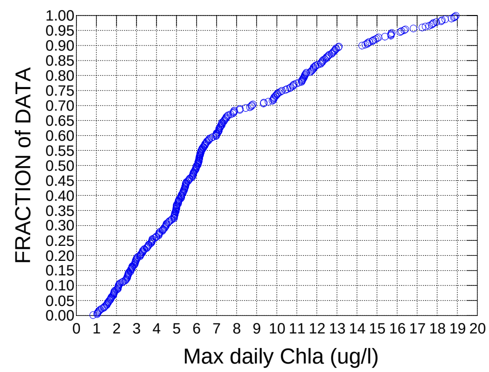
TALLYRAND



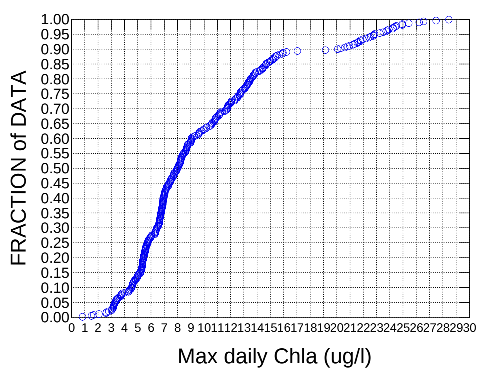
PINEY PT



MANDARIN



HIBERNIA



PICCOLATA